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OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

JULY, 1931

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SOCIETY OF MOTION PICTURE ENGINEERS

The Society of Motion Picture Engineers

Its Aims and Accomplishments

The Society was founded in 1916, its purpose as expressed in its constitution being "advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members."

The Society is composed of the best technical experts in the various research laboratories and other engineering branches of the industry in the country, as well as executives in the manufacturing and producing ends of the business. The commercial interests also are represented by associate membership in the Society.

The Society holds two conventions a year, one in the spring and one in the fall, the meetings being generally of four days' duration each, and being held at various places. At these meetings papers are presented and discussed on all phases of the industry, theoretical, technical, and practical. Demonstrations of new equipment and methods are often given. A wide range of subjects is covered, and many of the authors are the highest authorities in their distinctive lines.

Papers presented at conventions, together with discussions, contributed articles, translations and reprints, abstracts and abridgements, and other material of interest to the motion picture engineer are published in the Journal of the Society.

The publications of the Society constitute the most complete existing technical library for the motion picture industry.

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

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COLOR*

H. B. FRANKLIN**

Summary.—*Brief comments are made upon the difficulty which motion picture directors and technicians experienced when color was first introduced into motion pictures. The importance of color in motion pictures and the progress that has been recently made in color processes are pointed out. Emphasis is laid upon the necessity for steady experimentation in color values and the use of good taste in the adaptation of color.*

Color as shown in motion picture production was virtually thrown upon an unprepared public. The introduction of color in motion pictures has suffered to a great extent through the fact that motion picture producers and their technicians were not prepared to give it experienced handling. In the early part of the last production season, color was often introduced on the slightest pretext in many productions; producers did not have an opportunity to study the requirements nor perfect either the lighting or the apparatus to insure the best results. Consequently the color that was introduced so abruptly lacked the appeal that it could have had to motion picture audiences.

That there is a place for color in motion pictures is a foregone conclusion. In this age, when color has so much appeal, the motion picture cannot be expected to be immune. The appeal for color is fundamental. Our every-day life is constantly surrounded by color. It is up to the producers, however, to make a careful study of the uses to which it is best adapted. When motion pictures can capture the blending hues of the spectrum so that they dissolve into the scene, so to speak—and not dominate the picture as has been the case in some instances in the past—then color will enhance the pictorial as well as the dramatic values in motion pictures.

Much progress has been recently made in the introduction of perfected processes. A real competitive situation is now developing

* Presented in the Symposium on Color the Spring, 1931, Meeting at Hollywood, Calif.

** Hughes Franklin Theaters, Los Angeles, Calif.

which should result in the production of better methods and lower cost. In the past the cost of color has been prohibitive and producers have been reluctant to adopt it generally. Now that color can be introduced at virtually little more cost than black-and-white, a greater interest may be expected. It is fair to assume that the prices will adjust themselves to lower levels as color is more widely used. In an effort to encourage its further use, the manufacturers of raw stock have reduced its cost according to the quantity used. Important plants are equipped to handle great footage and maintain high quality, propositions which have been difficult in the older laboratories.

Intelligent study and experimentation on color values is necessary if producers are to derive the greatest value from this medium. In the past, producers have been tempted to crowd scenes with blatant colors in an effort to emphasize a wide range of color. Some of the rooms shown in colored pictures would unnerve most people if used in actual life. It is to be expected that the producer would use the same good taste in motion picture scenes that he would use in an actual home.

Lighting has been perfected to such an extent that it is unnecessary to handicap the use of color as it has been in the past, and with the new developments in photographic emulsions, a greater value may be placed on color as a medium. If the screen is truly to reflect life, it must eventually include color.

DISCUSSION

MR. SCHLANGER: In the motion picture theater, color is employed to create a mood in the patron. It is my feeling that color in the film should be used for the same purpose—to create a mood for the particular action on the screen rather than to show detail of color of the objects depicted. It is a delicate question as to what color will arouse the proper mood in the person viewing the film.

Color will be tremendously important in the future for the reason that theaters will become simpler in design and will not rely upon colored decorations on the walls, ceilings, domes, *etc.*, for creating the mood, as is at present done. The color on the screen might be utilized to take the place of colored decorations, the color being chosen so as to arouse the particular mood desired, and its reflection onto the simple decorations of the theater would provide the color projection which has before been suggested for the interior walls of a theater.

THE MULTICOLOR PROCESS*

RUSSELL M. OTIS**

Summary.—*A brief analysis is given of the way in which colors are reproduced using a two-color negative separation method. The Multicolor process, working on this principle, is briefly described. Details are given concerning the film used, camera requirements, exposure, development, printing, and coloring.*

The Multicolor process for making colored motion pictures belongs to the class of subtractive processes employing two-color separation. This means that in photographing, the light received by the camera is separated into two parts—the blue and the red components. Each of these components acts on a separate negative emulsion. Positives are printed from these negatives and are colored, the one printed through the red-sensitive negative being colored blue and the other one red. These two colored positives are superimposed in projection so that the light which has passed through one positive is absorbed (or subtracted from) in passing through the other.

Let us briefly consider how the various colors are reproduced. Assume that a gray object illuminated by white light will reflect toward the camera such amounts of red and blue light as will produce equal densities on the two negatives. The positives will then have equal silver densities and, if the color values are properly chosen, the resulting red and blue when superimposed will absorb equal amounts of the two complementary components of the projector light, resulting in only a decreased intensity, *i. e.*, gray, on the screen.

If the object to be photographed is not gray, but contains more blue than red, the red-sensitive negative will be less exposed than the other. The density of the positive printed from this red-sensitive negative will be greater than the density of the positive printed through the blue-sensitive negative. Since the positive printed through the red-sensitive negative is colored blue it is obvious that when superimposed the two positives will transmit more blue than

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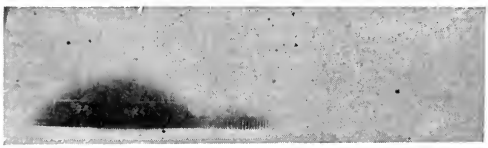
* Presented in the Symposium on Color at the Spring, 1931, Meeting at Hollywood, Calif.

** Hughes Development Co., Los Angeles, Calif.

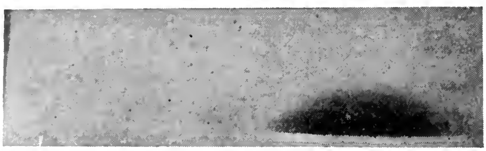
red light and the screen image will lean toward the blue. If the object to be photographed reflects more red than blue, the same analysis will show how the red tones are obtained.

It is not always appreciated that a two-color negative separation can result in many more than two colors on the screen. Most objects do not reflect a sharply defined spectral band but reflect to the camera light which affects both negatives to some degree. Hence a multitude of colors can be reproduced by making all possible combinations of red and blue densities. Thus many shades of blue, green, orange, red, and all the grays from white to black are obtained on the screen.

What has been said thus far applies to all two-color subtractive processes, but the methods by which these results are obtained in



Orthochromatic



Panchromatic

FIG. 1. Spectrograms of Dupack through No. 86 Wratten filter as used in daylight shots. Exposed in Hilger Wedge Spectrograph filtered to daylight.

practice vary greatly. The process used by Multicolor will now be described.

The separation of the two spectral regions in photographing is effected by the so-called bi-pack method. A special film with an orthochromatic emulsion and a standard panchromatic film are placed emulsion to emulsion, with the orthochromatic emulsion nearer the lens, and are run through the camera together. Blue or green light will expose the orthochromatic emulsion, but orange or red will not expose it due to the fact that this emulsion is not sensitive to orange or red. On top of the orthochromatic emulsion, on the side nearer the panchromatic film, is a layer of gelatin bearing a dye which

passes only yellow, orange, and red light. By this means, the panchromatic emulsion, which is sensitive to all light, is permitted to record the yellow and red portions of the picture. Spectrograms showing the regions of the spectrum recorded on the two negatives are shown in Fig. 1.

The camera used in photographing Multicolor pictures may be any camera employed for black-and-white work provided that a Multicolor double magazine for carrying the two negatives be used and that some special machine work be done to permit the camera to accommodate the two films and secure good contact between them. On the Mitchell camera a new pressure plate with four rollers is installed to insure good contact between the films and a shim is placed in front of the ground glass to make the ground glass plane coincide with the plane of emulsions when two films are used. This camera can then be used at any time for taking black-and-white pictures by simply removing the shim in front of the ground glass. On the Bell & Howell camera the pins on the back pressure plate are increased to eleven in number to insure contact, and 0.006 inch is removed from the aperture plate to make the emulsions come in the same plane as when previously only one film was used. In photographing, a No. 86 Wratten filter is used for daylight shots but is not used when the set is illuminated by incandescent lamps.

The prime requirement for good color balance over a wide range of exposure is that the gamma of the two negatives be the same and that the toe and shoulder of the H & D curve for one negative come at substantially the same points along the exposure axis as the toe and shoulder of the curve for the other negative. If the gamma of the two negatives is not the same it is possible to get a gray of only one density on the screen. If the H & D curves for the two negatives are displaced from one another so that the positions of the toes or shoulders of the curves do not coincide along the exposure axis, the efficient exposure range is narrowed to that between the toe of one curve and the shoulder of the other. In this process two negatives can be developed in the same time and in the same solution, and the success attained in meeting these requirements is demonstrated by Fig. 2.

Rather than try to correct in the laboratory for improper exposure of the negatives, the illumination on the set is measured with a photometer. If the proper exposure is obtained it is possible to develop the negatives alike, print them with the same light, and develop the

positive to a prescribed gamma, making the laboratory process nearly automatic. Generally, however, the printing lights are determined in the case of each scene by colored cinex strips. The determination of correct printing lights is one of the most critical operations in the laboratory process because it determines the relative density of the positive images, which in turn, fixes the color balance. A picture can be anything from an icy blue to a warm red, depending upon the choice of printing lights, and it is therefore essential that the man making the choice be equipped with facilities which enable him, when viewing cinex strips, to see the same thing that will afterward appear on the screen.

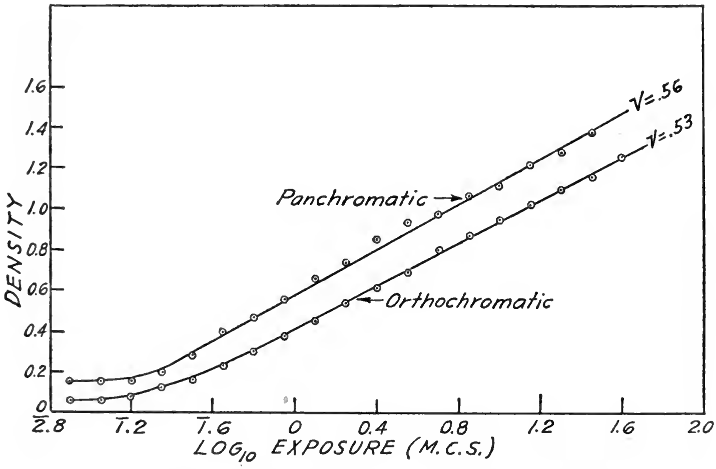


FIG. 2. H. & D. curves of Dupack exposed through Wratten filter No. 86 in E. K. Co. sensitometer filtered to daylight, and developed at multicolor by machine.

In printing, the two negatives go through the printer together, with a positive film between them. The positive film carries an emulsion on each side of the film support so that each positive emulsion is in contact with its negative emulsion. The two positive images are printed simultaneously by light coming from each side through one negative. The positive emulsions are blue-sensitive and carry a yellow dye to prevent light from one side exposing both emulsions. With the highest light used in printing, there is no exposure of the emulsion on the opposite side. The yellow dye washes out in the development process.

The main problem in printing is one of obtaining good registration, which can be obtained by using adequate mechanical devices. The shrinkage of the films, and worse yet, unequal shrinkage, is one of the greatest difficulties. Unequal shrinkage has been considerably reduced by employing negatives which are made at the same time on base from the same batch.

The positive is developed by machine to a prescribed gamma which has been determined by the condition that the contrast of grays in the picture shall be the same as that of the grays in the subject photo-

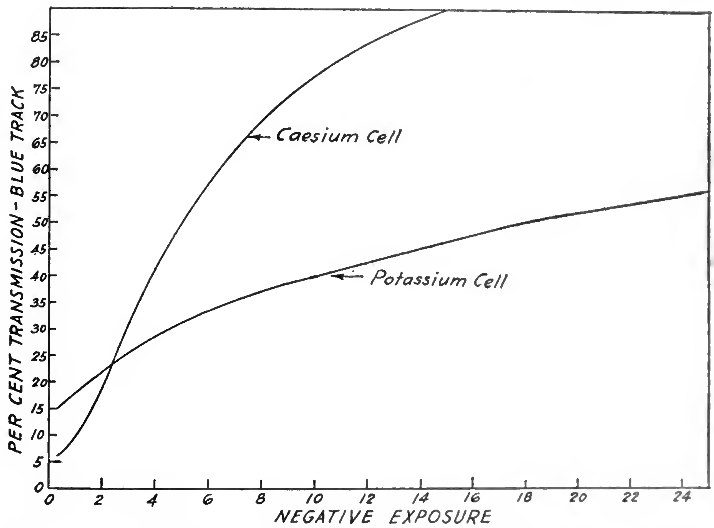


FIG. 3. Per cent transmission of blue positive sound track *vs.* negative exposure.

graphed. After fixing and drying, the film is then placed in the coloring machine.

The first operation of this machine is to apply a blue iron tone to one side of the film. Neglecting the washes, the film is then immersed in red toning solution which tones the image on the other side, leaving the blue image unaffected. This red uranium tone serves also as a mordant for a dye which next follows and which adds brilliance to the red image. The film is then passed through hypo after which it it is washed, dried, and varnished. This varnish greatly increases the life of the print, which is now ready for the projector.

The problem of the colored sound track deserves mention. There

is only one sound negative, so sound is printed on only one side of the positive, resulting in a colored track. A blue track has been found far superior to a red one. In variable density recording the blue track differs from the black-and-white track in the increased contrast of the blue over the black track before toning. Moreover, the relation between the response of a photoelectric cell to the transmission of the blue track and of the black before it is toned is not linear. The situation is further complicated by the recent introduction of the caesium photoelectric cell which gives a result different from that of the potassium photoelectric cell when used to reproduce a colored sound track.

The potassium cell is sensitive only to blue light, whereas the caesium cell responds also to red light. The effect with a black-and-white sound track is simply that the caesium cell reproduces with greater volume than the potassium cell. But when used with a colored track, the relation between the blue density and the black density is entirely different for the two cells, resulting in not only a difference in volume but generally a difference in quality as well.

A study of the sensitometry of the blue track and recording tests made with it, however, have demonstrated that excellent results can be obtained with both types of cell if the sound negative is correctly exposed and if the remainder of the processing is properly done. It is particularly fortunate that the normal development of sound negative to a gamma of about 0.5 is still found to be the most suitable when the sound positive is toned blue.

The essential property of a good sound record is that there exists a linear relation between the transmission of the positive as viewed by a photoelectric cell and the exposure of the negative. Fig. 3 shows this relation for the Multicolor blue track as seen by both caesium and potassium photoelectric cells.

THE MULTICOLOR LABORATORY*

BRUCE BURNS**

Summary.—*This paper sets forth the manner in which the lay-out of the Multicolor Laboratory was made to provide efficient handling of all processing media, as well as film itself. A chart shows the flow of film through the various stages of handling and processing. Emphasis is laid upon the major precautions taken to protect all film, and particularly negatives, against damage of any sort at any point in the plant.*

Whenever a new laboratory for the processing of motion picture film is erected, the engineers of the industry naturally are interested in both the general layout and the particular features of design of building and equipment. In this paper will be briefly given a general picture of the new Multicolor Laboratory, placing some emphasis upon the features of design which are adapted to the special characteristics of the process, and the precautions which have been taken to insure safety to the product at all stages, particularly with regard to negatives.

Fig. 1 shows a floor plan of the building, on which appear all film handling departments with the exception of the daily review room. In addition to these and the rooms containing equipment incidental to processing, such as boiler room, compressor room, refrigeration room, air conditioning room, *etc.*, the first floor houses the general offices, the superintendent's office, the camera department, one projection room, the electrical shop, a transformer room, a garage, and a room for general purposes, designated as the tank, repair, and storage room.

No plan of the second floor is shown; it has approximately one-third the area of the ground floor, and in addition to the daily review room it includes four suites of executive offices, the research department, a theater, telephone room, *etc.*

The heart of any film laboratory is its processing room, and the rooms for further treatment of film must be efficiently grouped around this unit. Since practically all other departments of the plant have

* Presented in the Symposium on Color the Spring, 1931, Meeting, at Hollywood, Calif.

** Hughes Development Co., Ltd., Los Angeles, Calif.

to handle film before it goes to the processing room or after it leaves the room, the disposition of these other departments should be such as to provide the nearest approach to continuous flow of the film through the plant.

Similarly, since the chemical room must supply processing chemicals to the machines and receive chemicals from them, and the air conditioning equipment must furnish air for drying film in the machines, both of these departments must be placed nearby. The power plant in which will be located the boilers to supply steam for heating the air during conditioning should be close to the air conditioning equipment. The compressor room, in which are located compressors for refrigeration and film squeegees, must be located properly both with regard to the processing room and the air conditioning equipment.

Since it is evident that the size and shape of the processing room depends to a considerable degree upon the characteristics of the machines employed, the first step in the lay-out of the plant is the selection of the proper processing equipment. When this has been determined, for the given capacity, the dimensions of the processing room are virtually fixed and the other departments of the plant may be arranged around this room.

The processing machines are of the continuous, multiple-strand, horizontal run type. Each machine is approximately 180 feet long in the wet end, and carries the same length of dry box to insure ample drying capacity under all conditions at a minimum temperature. The ten processing machines lie side by side in pairs with the dry boxes disposed on a mezzanine deck overhead. These machines occupy a processing room 44 feet wide and 225 feet long.

At the east end of the processing room are placed the five air conditioning units, each with a capacity of 12,000 cubic feet of air per minute at a wet bulb temperature of 75°F. maximum, which is ample for drying. The boilers for supplying steam to the air heaters are located south of the air conditioning equipment; the compressors and brine tank for supplying refrigerated water to the dehumidifiers are immediately west of the boiler room.

The chemical room with floors or mezzanines on three levels is a narrow alley extending along the entire south side of the processing room; it contains the mixing tanks, circulating pumps, circulating tanks, and sump tanks for all the machines.

Film handling rooms for work on the film before and after passing through the processing room are placed along the north side and west

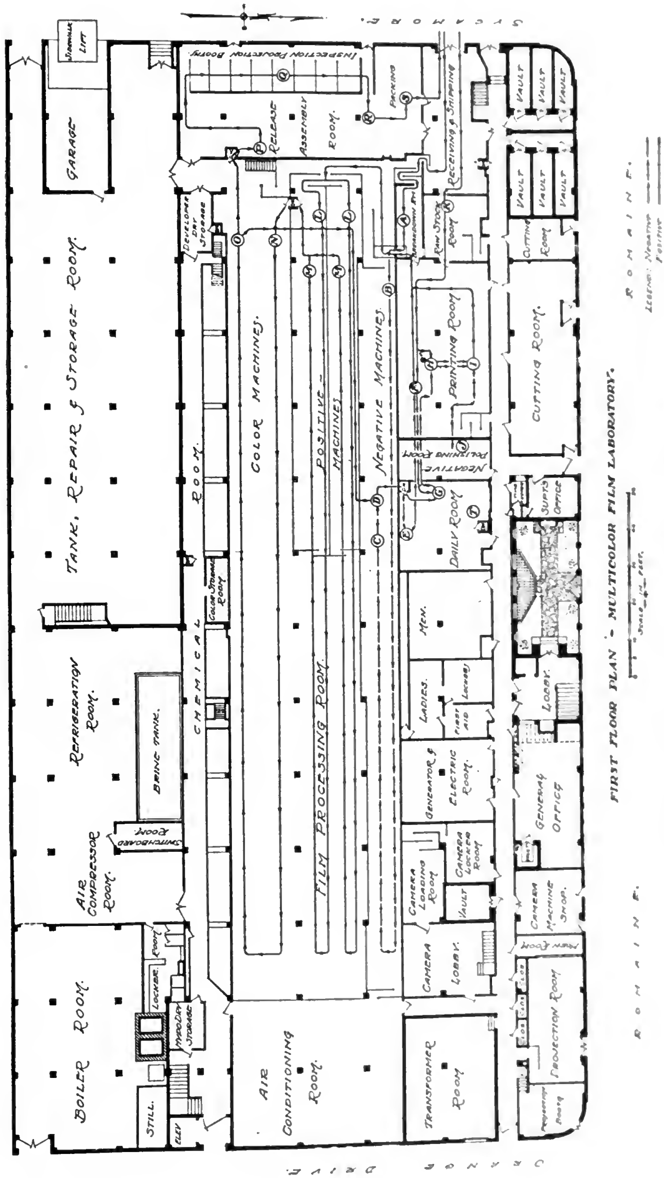


FIG. 1. Floor plan of the Multicolor Laboratories.

end of the room. The air conditioning equipment for this group of rooms is placed in the basement at the southwest corner of the processing room.

The printing room is equipped with Bell & Howell printers for sound track, and with Hughes Development Company step printers for picture. The latter have been designed with the specific requirements of the Multicolor process in mind. They print from both negatives simultaneously onto the positive stock, thus insuring perfect contact, register, and light balance. Each printer normally operates at a speed of 21 feet per minute, but, if desired, can be operated at either lower or higher speeds. All picture printers are equipped with automatic light changes, which make it possible for the operator to devote his entire attention to the work of the machine, and although the printing operation is carried out on both sides of the film at once, a special inspection window with a mirror permits the operator to observe the film at the printing aperture at all times. In case any doubt arises in the operator's mind regarding any phase of the machine's operation, he can stop and start it again between frames without affecting the finished print.

By following the path of a roll of exposed double Multicolor Rainbow negative from its entrance in the receiving department through the various steps in negative processing, and then following the positive until it arrives at the shipping room door, we can see how the plant lay-out adapts itself to straight line flow. Referring now to the floor plan, we see that from the receiving room door the pair of negatives goes to the breakdown room, *A*, where tests are cut off and spliced into rolls for the negative developer. These tests are passed through a chute to the negative room and loaded on the machine at *B*. They go eastward through the negative machine, turn up at the east end of the process room to the dry boxes, and return to the west end of the room, where they are unloaded at *C*. Light tests are read at *D* and the results communicated to the breakdown room, where negatives requiring the same time of development are spliced into rolls and sent through the chute to the negative machines. From the loading point, *B*, they follow a course similar to the tests, are unloaded at *C*, and sent through the dumb waiter to the daily room. At *E*, rolls from the same production are made up and are sent to the cinex machine, *F*, where cinex exposures are made, after which the negatives are returned to the daily room at *G*.

Raw stock goes directly through the receiving room into the raw

stock room, *K*, from which it is supplied as needed for printing. Stock which is used for cinex exposures goes to the cinex machine at *F* and thence through a chute from the printing room to the west end of the processing room and through the light lock to the loading end, *L*, of a positive machine. As in the negative developer, films in the positive developer are developed, fixed, and washed on their trip to the east end of the room and are dried on their return to the west end on the upper level. They are taken from the positive machines at *M*, sent through the dumb waiter to the loading end, *N*, of the color machines, and go east through the wet end of the color machines and are dried in returning westward to point *O*. From this point cinex strips go to the light reading table, *D*. Selection of proper printing lights is made, and the strips are sent through the dumb waiter to the daily room. Here, at *G*, the negatives are notched for light changes and light change cards are made out. From this point negatives go to the sound printer, *H*, then to the picture printer, *I*, and in the case of dailies they return to the daily room for transfer to the vault; in the case of release prints they shuttle back and forth between the printing room and the negative polishing room, *J*, according to polishing requirements.

The daily and release prints go from the picture printer, *I*, through to the positive and color machines following the same course previously outlined for cinex strips. Before being removed from the color machine at *O*, prints are varnished and dried. Daily prints return in the same manner as cinex strips to the daily room, projection reels are made up and go through the dumb waiter, *T*, up to the projection booth of the daily review room on the second floor, which is conveniently located with respect to the research department and sales department offices. Release prints leaving the color machines at *O* drop through a dumb waiter to release assembly, *P*, from which they go through inspection booths, *Q*, to hand inspection, *R*, where standard leaders are spliced on; from this point they go through the packing department, *S*, to the shipping room.

Reference was made at the beginning of this paper to the safety precautions which were taken in the design of the building and equipment; a few paragraphs will point out the highlights.

The processing machines are so constructed that every strand of film is instantly available to the operator at every stage of the process. This permits continuous inspection, and in case a situation requiring immediate attention arises the operator can act at once without having

to shut down the machine or wait for a length of film to run through one or more steps of the treatment.

Although each air conditioning unit has a normal capacity, nearly twice that necessary for drying its quota of film, all five air conditioning units are cross connected, so that in case of insufficient performance or complete failure of one unit the others may be called upon to carry the load.

To guard against the possibility of a power failure stopping the machines with film in them, two thirty-three thousand volt lines from different power systems have been brought into the building, and in the transformer vault change-over switches are provided to shift the entire load from one line to the other in case the power is shut off. In addition, on the negative developing machine, a hand drive is provided so that in the very remote case, where both sources of power fail, the operator can withdraw from the developer through the stop bath into the hypo all film which may be actually in the course of development.

To guard against the possibility of water spots, double squeegees are used in series, so constructed that they may be cleaned while the machine is operating.

Air for the squeegees is supplied by two double acting compressors, each driven by a two-speed motor. Under normal operating conditions both compressors running at half speed will carry the full load with an ample margin of safety. In case of failure of one compressor, the other, running at full speed, takes the entire load until the unit which has failed can be repaired, or the quantity of film in process has been reduced to half capacity.

Similarly, two boilers are provided for the air conditioning and distilled water service, either one of which is ample to take care of full production requirements.

Three ammonia compressors are used for refrigeration in the air conditioning units. Under normal atmospheric conditions, one of these machines alone will carry the total load. All compressors and fans are driven by multiple V-belt drives, so that failure of one or more belts will not necessitate shutting down any unit.

In the circulation of chemicals, excess pump capacity has been provided. Where one pump will normally carry the load, another pump of equal capacity is always in reserve. Where two pumps are required, an additional pump is provided to relieve either one. Also, large circulating tanks with a gravity flow to the processing machines

have sufficient reserve capacity to make it possible to run film out of the machines in case of complete failure of all pumps.

Two wells in the basement at opposite ends of the building, each with a capacity equal to normal wash water requirements, provide wash water of uniform and known chemical characteristics and temperature in winter and summer, but, in addition, a main from the city's water supply having sufficient capacity for the entire plant comes into operation automatically as needed.

The building is constructed of flat slab reënforced concrete throughout and probably merits as nearly as modern construction can make it possible the appellation "absolutely fireproof." Automatic sprinklers of the fusible link type have been installed in every room in the plant. In addition to this, extremely sensitive thermostats instantly responsive to slight but rapid changes of temperature, have been installed where considerable quantities of film are to be stored or handled. As further evidence of the extreme precautions which have been taken to guard against fire, automatic sprinkler heads have been installed under cutting tables and in other places where appreciable quantities of loose film may easily accumulate.

Reënforced concrete film vaults with specially constructed steel shelves are provided for storage of customers' negatives, and each vault has been made small so as to reduce to a reasonable minimum the amount of film concentrated at any one place.

All film, whether negative, raw stock, or developed or colored positive, is handled in specially constructed air-tight and light-tight, heavy gauge steel cans at every stage of its travel through the plant, except when it is being actually handled on one of the machines.

Various minor precautions too numerous to mention have been taken to eliminate as nearly as possible all fire hazards; the success of this program is reflected in the fact that the Multicolor Laboratory carries the lowest fire insurance rate of any film laboratory in the United States.

THE LATIN AMERICAN AUDIENCE VIEWPOINT ON AMERICAN FILMS*

C. J. NORTH AND N. D. GOLDEN**

Summary.—*English language pictures accompanied by adequate Spanish titles still find favor in the chief markets of Latin America. Latin-American audiences want box-office personalities and through Spanish editions of our fan magazines nearly all our stars have built up a strong following. In consequence, pictures presenting them are more popular than Spanish versions in which the players are unknown.*

This does not mean that no Spanish language pictures should be presented. Great care should be taken in their preparation, however, and original subjects should be used of a type which have special appeal. Castilian Spanish, the language of the stage, should be used, unless the setting is in a Latin-American country where the actors would use the pronunciation and idioms peculiar to that country. None of the foregoing applies to Brazil, where the language is Portuguese. Here Spanish speaking pictures are not acceptable.

The tastes of the Latin-Americans run to films containing much display in clothes and furnishings. High society pictures and musicals are both popular.

While Latin-American revenues from film showings are not nearly as high as those received from Europe, the market is nevertheless well worth consideration. Argentina, Brazil, and Mexico stand fourth, seventh, and eighth, respectively, in quantity of motion pictures imported from the United States. There are about 900 theaters wired and the number is rapidly increasing.

Last fall, at the New York meeting of the Society, the writers endeavored to outline in some detail the position of the American sound film in Europe. In this paper we are turning to Latin America. By so doing, it is intended to strike a somewhat different keynote, in looking at American films from the viewpoint of the audiences in the major Latin-American countries and attempting to indicate the type of film they like, placing special emphasis on the obstacles which the use of dialog has raised in an essentially non-English speaking region. For after all, while the audience is "king" in Europe as well as anywhere else, the European film situation is dominated by competition and government restrictions against our films. In Latin America both

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Chief and Assistant Chief, respectively, Motion Picture Division, Bureau of Foreign and Domestic Commerce.

of these are happily absent and therefore the road to the box-office is comparatively free from those disturbing factors which so complicate the European situation.

The fact that the bulk of our motion picture revenue comes from Europe should not blind us to the importance of the Latin-American market. After all, during 1930, over 73,000,000 feet of film from the United States were exported to the countries south of the Rio Grande. Argentina took from us nearly 17,000,000 feet of finished motion pictures and is our fourth largest market in quantity of films imported, while Brazil and Mexico, taking 11,312,000 feet and 9,417,000 feet, respectively, stand seventh and eighth. In addition, an aggregate total of over 5,000,000 feet of film was sent to Chile and Cuba, over 3,000,000 feet each to Colombia and Peru, and over 2,000,000 feet each to Venezuela and Uruguay. It should be noted, furthermore, that these figures represent showings of American films in all these countries averaging well above 80 per cent of their entire screen time.

Latin America is still relatively deficient in number of wired theaters. Latest figures supplied by the Department's field men show that as yet only about 900 out of 5300 theaters are equipped for talking pictures. However, these comprise nearly all the large first-run theaters, which supply a much larger proportion of revenue than their number would indicate. Furthermore, theater wiring is proceeding at a rapid rate.

With this general picture of the situation in mind, the next question that arises concerns the kind of pictures that Latin-American audiences want to see. A rule-of-thumb answer to this question is, of course, impossible. However, we will present here a few impressions which have originated from our highly efficient trade scouts on the spot.

In Cuba—to begin with a market close at hand—it appears that the women set the standard in films as they do in our own United States. That is to say, the society picture with elaborate costumes and settings is the prime favorite, although films of college life and, to a smaller degree, musicals are also popular. Westerns do not seem to enjoy much favor except among a limited portion of lower class audiences.

As far as language is concerned, there seems to be a division of interest. For instance, in the five first-run houses in Havana and in the two movie houses in the fashionable Vedado residence district, dialog films in English predominate, due to the fact that these theaters are

frequented by Americans, English speaking foreigners, and by Cubans who, through travel and education, are more or less familiar with English. However, it is worthy of note that when such films enter the second- and third-run houses they are good for runs of only two or three days, as compared with a run at least three times as long for Spanish dialog features. This is true even in cases where the film in English presents popular stars and actors.

In general, there has been no unfavorable reaction to the employment of actors of different nationalities speaking the Spanish language. Naturally, if the setting of the film lies in a given Latin-American country, such as Mexico or Argentina, it would be expected that the actors would use those peculiarities of idiom and pronunciation peculiar to those countries. It would also be expected that the diction and grammar of an actor would be in keeping with his station and environment. The anomaly of a day laborer speaking high-class Spanish would be quite as absurd as its American counterpart. But aside from these obvious limitations the use of Castilian Spanish for the average dialog film would be understood and appreciated by the Cubans. It may be added that virtually the same situation exists in Porto Rico, both as to tastes and type of language in favor.

Turning now to Mexico, we find an interesting and peculiar situation. There has been, and still is, a press campaign of considerable magnitude to ban the showing of all films in Mexico not in the Spanish language, and this campaign has had its effect in an attempt to exclude English dialog films by official decree, which so far has not come to anything. And yet, English language films are well received, particularly in Mexico City, and have a smaller though fair popularity in the large interior towns. Even the uneducated and semi-literate movie-goers do not object to English dialog if the pantomime and action is sufficient to make the story clear.

An interesting experiment conducted in Mexico City not long ago by one of the large American companies illustrates graphically the relative box-office appeal as between English and Spanish dialog pictures. This company showed the English version of one of its productions in one theater and the Spanish version in another theater of relative size and catering to the same general class of audience. At the end of a week the company in question received the cheerful news that each theater had done better than average business and that the theater showing the Spanish version had grossed just $20 more than the other.

There have been two obstacles to the popularity of Spanish dialog films in Mexico. First, the value of the star cannot be overestimated. Mexican movie-goers read Spanish editions of the fan publications. They know all the American stars and they go to see them play in English, as against a picture in Spanish where the actors are comparatively unknown. Of course, where American stars can speak Spanish, their popularity is just that much increased, but even though they speak English, they will not lose popularity until such time as Spanish actors develop a real star of their own. It might be added that one of the most popular types of film in Mexico is the American comedy in which the star for purposes of humor speaks what is referred to as "gringo" Spanish.

Another reason why Spanish language films have not been more sucessful is that many of the Spanish actors employ dramatic gestures and declamation which the Mexicans do not like nearly as well as the more simple and natural style of acting used in English language productions. As for the type of Spanish employed there is no objection to Castilian, if in part, but again, as in Cuba, great care should be taken to have the actors talk according to type, class, and environment.

In South America itself, our first and second markets are Argentina and Brazil. These have 1360 and 1600 theaters, respectively, while the former has about 260 and the latter about 200 theaters wired.

Argentina has proved one of the greatest sources of difficulty for producers of Spanish language films. The taste of the people is essentially for high society films of a spectacular nature and for musicals. Sophisticated themes also appeal. Furthermore, the Argentine public has its own particular ideas of Spanish and hence even the classical Castilian, which proves satisfactory (in its proper setting) throughout most of Latin America, is not very popular here. In short, Spanish dialog films have had only limited first-run success, though the desire for Spanish is strong enough among the lower classes to bring small profits in second- and third-run showings.

Another and more important reason for the unsuccessful showing of Spanish dialog pictures is the lack of personalities which mean as much to the Argentine fan as to fans anywhere. Only special talent in Spanish casts of a type not discernible as yet can overcome this obstacle. And so we find the English dialog films with superimposed titles in Spanish ruling the roost and apparently destined to dominate the 1931 winter season. This, by the way, is in the face of a certain

amount of official and press opposition to the use of anything but Spanish in films shown in Argentina.

Brazil is the single large Latin-American country in which Spanish is not spoken. The language is Portuguese and, while it is closely allied to Spanish and the people in general can understand that language, Spanish films are not acceptable. It therefore becomes a matter of showing films in Portuguese or in English with superimposed titles. Obviously, it is not financially expedient to produce Portuguese versions except in special cases and even here those box-office names so dear to the hearts of the Brazilian fan are conspicuous by their absence. All told, the past year has shown that American talkies with Portuguese titles superimposed adequately and understandingly are working satisfactorily. Dubbed pictures are not successful excepting in the case where a caption is flashed on the screen together with a definite statement that the picture had been "dubbed" in the interests of realism. This was done by one of the exchanges in the case of a well-known picture and the audience took the inaccuracies of lip movement in good part.

The past year has also demonstrated that the films which have been big box-office attractions in Brazil are drama done on a large scale with elaborate effects and plenty of action. Musicals, excepting revues, have fair popularity and high society portrayals are always effective. Comedies not purely slap-stick get good returns, but typically American themes, such as the gangster film, do not go very well.

The types of sound film most popular in Chile are the drama and musical revues. English language pictures were originally received enthusiastically and were very successful, but a sudden reaction has taken place and it seems that public interest in English speaking productions is on the wane.

The change from the silent drama to sound reproductions was a revolution in showmanship and a novelty to Chileans. The novelty has since disappeared, and several productions in Spanish have been shown and enthusiastically received by the movie patrons of Chile; the transition in public taste is toward Spanish dialog films.

An indication of the above enthusiasm is well illustrated by the receipts of three American pictures. Two of these pictures each brought in about 200,000 pesos. In contrast, the third American film, featuring a well-known American star capable of speaking Spanish, it is estimated will bring upward of 450,000 pesos to its distributors.

This is not to say that English dialog films in Chile with superimposed titles are entirely out. The great majority of the better educated class understand English and, furthermore, English is widely taught in the schools, as being the recognized language of commerce. It does, however, indicate that pictures having stars who are capable of speaking a type of Spanish not offensive to Chileans will have an edge in this market over those English dialog films with superimposed Spanish titles. But, as between an average Spanish version and a quality English dialog film with Spanish titles superimposed, the latter is at all times preferred.

An interesting letter has recently been received from our Commercial Attaché in Colombia, which describes the situation in that country. He writes, among other things, "I have observed the reaction to talkies in Spanish and in English with Spanish titles, and have come to the conclusion that the latter combination is more successful." Perhaps the outstanding reason for the preference is that the actors and actresses in the Spanish versions are not as finished and well known as English speaking artists. Let the American producers continue to feature the well-known stars, have the parts announced in good Spanish, or insert brief but complete translations with the picture, a few musical numbers in Spanish, and the public will be satisfied. The Colombians like plenty of action, whether love, drama, or wild west scenes, and good music. In short, motion pictures with action and good music are the types that are attracting the public to the theaters.

Peru with its 13 wired theaters also shows a predilection for the musical picture and the society drama. The opinion of the local public is divided, according to the opinion of our Commercial Attaché in Lima, as to whether English or Spanish dialog is preferred and as to the type of pronunciation which should be used in the Spanish dialog. Those who speak and understand both languages prefer English because they claim that the English speaking actors are better. Good Spanish artists are preferred by those who do not speak English because of the Spanish dialog, but they claim that the majority of Spanish actors have not been trained to acquire motion picture technic, and therefore, the American box-office names are preferred at present by the greater part of the public. The local public does not want the dialog cut out because it is in English (which has been done with bad results several times in the past) for the reason that, among other things, the younger generation in Peru likes to follow English

dialog because it helps them to perfect their knowledge of the language. As to the pronunciation preferred in Spanish versions, pure Castilian, when not too exaggerated, is acceptable. The public is accustomed to hearing Spanish actors on the legitimate stage, where Castilian is the accepted language.

It would be of interest at this point to quote the conclusions of the various consuls of Latin America who met in San Francisco recently at the suggestion of Don Sebastian de Romero, Consul of Spain, in that city, relating to the Spanish language to be used in talking pictures:

"The Spanish language represents a complete unity to all those countries speaking it, with the exception of a few small differences in dialects pertaining to the different regions. The Spanish language as spoken by the cultured people of Latin America is as pure and as grammatically correct as that spoken in Spain by the same class of people.

"We consider it worthy for all countries speaking our language to accustom their pronunciation to that of the Spanish language as spoken in Spain. In view of the fact that the sound picture is one of the best means for obtaining this uniformity in language, it is to be hoped that the actors taking part in these talkies will have a correct and pure pronunciation. There are, of course, in some of the Latin-American countries, as well as in the different provinces of Spain, certain accents and colloquialisms which will not be admitted in the talkies unless the parts are characterizing individuals of those countries and provinces."

From all that has been said we must draw the highly surprising conclusion that the American product with Spanish sub-titles is more popular in the majority of Latin-American countries than the Spanish versions which are at present being shown. This should be good news to the producers who, having been told to produce films in the language of the particular country (still true in Continental Europe, by the way), are spending large sums in putting out Spanish versions of their product. However, it is not intended to assume that Spanish versions are, or should be, dead. Well done films in Castilian Spanish (except where special circumstances decree otherwise) will gain greater popularity in direct proportion to the time and care that is put on them, and it is quite likely, as Spanish box-office names are built up, that they may outstrip the American. The moral of the whole story is that Latin Americans—as do fans everywhere—go to see personalities—a fact which producers sometimes overlook.

DISCUSSION

MR. CRABTREE: What is meant by superimposed titles? Does the action proceed in English and stop at a title interpreting what has gone before in Spanish, or does the title tell what is going to come?

MR. GOLDEN: The superimposed title is on the set itself while the actors perform. It is seen in a lower corner of the picture, and explains the lip motions of the actors In Japan and China, and in certain portions of India and Greece, a separate screen is used, on which is projected sub-titles which explain the action shown on the main screen.

MR. GRUBER: Many English films have been translated into many languages, including Japanese and Polish; the Paramount eastern laboratories have done considerable work of this kind.

MR. HICKMAN: About three months ago, in South America, I viewed two or three Latin-American films. On one side of the street was a theater showing an English-speaking talkie having Spanish titles superimposed on the sub-title, *i. e.*, on top of the film action. Across the street a Spanish movie was going on. The all-Spanish movie sound reproduction was extraordinarily good and there was not a seat vacant in the entire house, which had a seating capacity of about 1500. The people gathered there half an hour before the show. On the other side of the street, where the superimposed picture was being shown, there were not fifty people in the theater.

MR. GOLDEN: This might be true under certain circumstances, but reports on the situation have convinced us that it applies only when the natives of the particular country have seen the native actors; eventually they want to see our American stars.

MR. CRABTREE: Perhaps, Mr. Böhm, you can tell us something of the German situation. Is the German language used in all the films or is English used in some of them?

MR. BÖHM: Two years ago there was really no production of German sound films in Germany. Since then American films have been shown. The first one was the *Jazz Singer*, in which the procedure outlined by Mr. Golden was followed. After seeing one or two pictures of this kind the German audience quickly came to dislike the superimposed titles. They wanted to have German films and hear the German language, but, in addition, they were prepared to listen, as a curiosity, to foreign films in their own language. Superimposed titles have entirely disappeared in Germany in the last year and a half. Now the production of German-speaking films is very great and amounts to 100 to 120 feature films per year.

MR. CRABTREE: Is it not annoying to have the hieroglyphics blotting out some of the detail of the picture?

MR. BÖHM: It is very disturbing, because one does not know whether to watch the action or read the lines. Translations are only of little help, since they detract the attention from the action, and I do not think that this kind of assistance to the distribution of film in foreign countries will last. The use of superimposed titles does not answer the problem of foreign film distribution; it merely furnishes a means of presenting American stars to the foreigner and gives him the continuity of the story.

MR. KING: In China an additional screen is placed near the main screen, about $1^1/_2$ ft. high and 3 ft. wide, on which still slides are shown. Three years ago the Chinese titles were placed immediately below the English title.

MR. GOLDEN: I might also add that in Japan men known as "benshi" are employed to explain the action of the picture, as it proceeds, to those who are not capable of grasping the continuity without the aid of titles.

IMPROVEMENTS IN MOTION PICTURE LABORATORY APPARATUS*

C. E. IVES, A. J. MILLER, AND J. I. CRABTREE**

Summary.—*A number of miscellaneous improvements in laboratory apparatus are described, which have for their object the elimination of spots, scratches, and unevenness of density in processed motion picture film. Modifications in developing room equipment include a vacuum cleaner for removing sludge from developers, a cooling coil for adjusting developer temperature, a new type of rack guide for a developer tank, a compact rack light lock, a waterproof and corrosion-resisting portable darkroom lamp, and some auxiliaries for the prevention of spots and contamination on film.*

Improvements in printing room equipment include the addition of a flywheel to a continuous printer to eliminate unevenness in density due to variation in the motion of the film during exposure. Also, a light change has been equipped to control either of two lamps of different wattage giving in each case exposure values which have precisely equal relationships.

Some changes have been made in rewinding equipment which include the addition of a weighted roller to make more firmly wound rolls and a large portable winding core. The design of a standard disk rewind has been changed to facilitate removal of the wound roll.

A film storage cabinet has been designed for laboratory use which gives an increased degree of protection from fire and water, at the same time assisting in the convenient and orderly arrangement of the film.

Although essentially similar methods are in vogue for handling motion picture film in different laboratories, a great variety of equipment is employed for the various operations involved. This is due not so much to obsolescence as to lack of coördination of effort in designing equipment.

It is the purpose of this paper to illustrate and describe some miscellaneous improvements in various types of laboratory equipment. Although parts of this paper dealing with rack equipment may be of little interest to those who use developing machines, it is hoped that they will be of value to many of the smaller laboratories which will undoubtedly use the rack system of processing for some time to come.

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** Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

DEVELOPING ROOM EQUIPMENT

Developer Clarification.—With normal use, developers accumulate solid material which is in a fine state of division and remains in suspension for a considerable period of time owing to the agitation which the liquid receives. In the case of the almost universally used developers of the "borax" type which contain a large proportion of sodium sulfite, a dark-gray sludge consisting partly of silver accumulates in the solution. The presence of silver is accounted for by the reduction to metallic silver of the silver halide dissolved out of the film emulsion by the sulfite.

As the quantity of this material in suspension increases, it deposits on the emulsion surface of film processed in the developer and remains

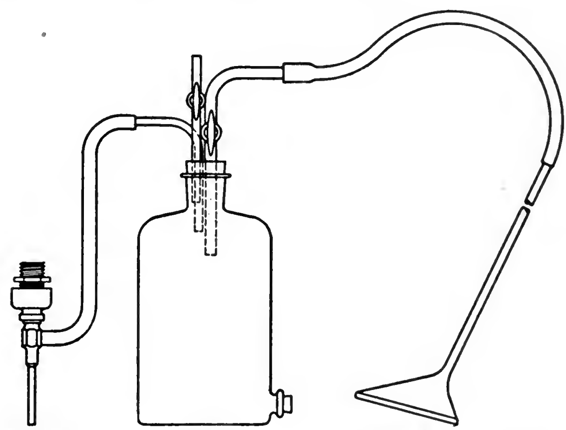

Fig. 1. Vacuum cleaner for sedimented sludge including water pump, trap, and nozzle.

after the operations of fixing and washing are completed. Unless the squeegeeing or scouring operation is most carefully done, an objectionable quantity of the muddy residue remains on the film in the form of streaks which are noticeable on projection. No method has been found for preventing the formation of the mud but it can be removed from the developer by common methods of clarification.

It was found that in a 120 gallon tank, 4 feet deep, a large proportion of the solid material would settle out from the developer upon standing overnight. After standing for twelve hours the largest proportion of the material settles to within a distance of about 1 inch from the bottom of the tank.

Fig. 1 shows diagrammatically a device with which the sludge was removed from the bottom of the tank without causing any general agitation in the liquid. It consists of a metal vacuum nozzle shaped to lie on the bottom of the tank and held by a $^1/_8$-inch pipe which serves both for the vacuum connection and as a handle. The end is connected by a soft rubber tube to a laboratory water pump. A glass trap is inserted in the rubber pipe line to protect the pump and to permit continuous inspection of the sludge so that the operator may advance the nozzle along the bottom of the tank at a suitable rate. The water pump is especially suited for this work because it develops sufficient vacuum for the purpose while the liquid is being raised but does not pump so fast as to cause an excessive flow of liquid. It was found that by using an experimental tank with glass walls, a nozzle of the type illustrated could be inserted in the tank and drawn along the bottom without scattering the mud. With a 120-gallon tank the settled mud could be removed without taking out more than one gallon of liquid.

If the developer is moved continuously in a large circulating system it might be possible to remove the sludge by continuous filtration. Alternatively, the main supply of developer might be divided into two or more parts so that sedimentation may take place in one part while the other is in use. The solid residue taken from various samples of developer showed, upon analysis, between 13 and 47 per cent silver so that it is of sufficient value to be included with other silver waste.

Temperature Control.—In the rack and tank process of developing where a recirculating system is not used, the developer temperature is likely to be other than what is desired after standing overnight. The temperature-control system, which functions while the developer is in use, should be designed to prevent a change in temperature due to continuous heat exchange and is therefore not usually capable of making a large change in the whole body of liquid in a short time. When a quick change is necessary, it has been found convenient to insert temporarily in the developer a length of metal pipe through which hot or cold water is circulated. For convenience in handling the pipe it has been found desirable to support it on a developing rack as shown in Fig. 2. By using about 18 feet of lead tubing and passing in water at a temperature 10 to 30 degrees higher or lower than that of the developer it is possible to change the temperature of 120 gallons of developer several degrees per minute. Thin tubing of a corrosion-

resisting metal such as monel or high chromium-nickel steel will permit greater heat transfer but the lead is satisfactory and is very easily shaped.

Rack Guides in Tanks.—In order to permit proper manipulation of the rack in a developing tank[1] it is necessary to leave room for its lateral movement. The ordinary type of rack guide which permits practically no laterial movement is quite unsatisfactory. Fig. 3 shows a two-rack stone tank fitted with maple rack guides which, while permitting considerable lateral motion of the rack when fully under the surface of the liquid, hold it in such a way when locked that no part of the film comes in contact with or dangerously near any part of the tank.

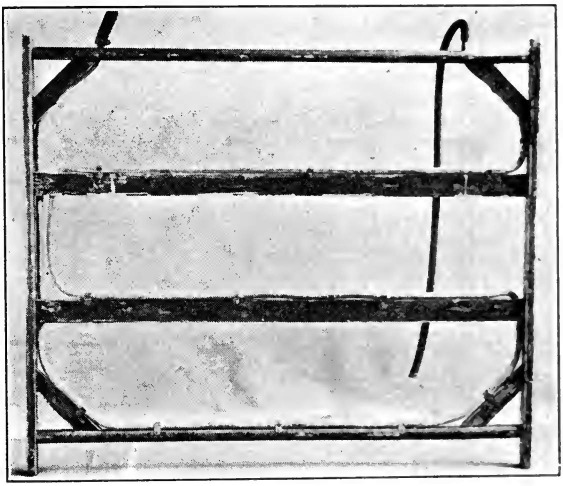

FIG. 2. Cooling pipe mounted on developing rack.

It will be noticed that the whole assembly of wood at each end of the tank is attached to the center guides which extend from top to bottom of the tank. They are kept in position at the bottom of the tank by means of a hole into which they fit and at the top by attachment to the wooden framing which surrounds the tank. Rotation is prevented by the flat side which they present to the end of the tank. A slot is cut in one guide to make room for the thermometer and in the other for clearance around the drain hole. Allowance is made for expansion of the wood both where the peg enters the bottom of the tank and at the ends of the cross-piece holding the lower outside

guides. Maple has been found more satisfactory for work of this kind than cypress, which is often used where it is to be in contact with water. No trouble is experienced from warping, probably because the wood is wet equally on all sides. Wooden dowel pins are used exclusively for joining the pieces which are to be in the liquid.

When the rack is first lowered into the tank considerable freedom of motion is permitted, but when it is pushed down far enough to slip under the ledges which hold it in place it comes to the lower side guides which deflect it inward from the tank wall toward the center guide.

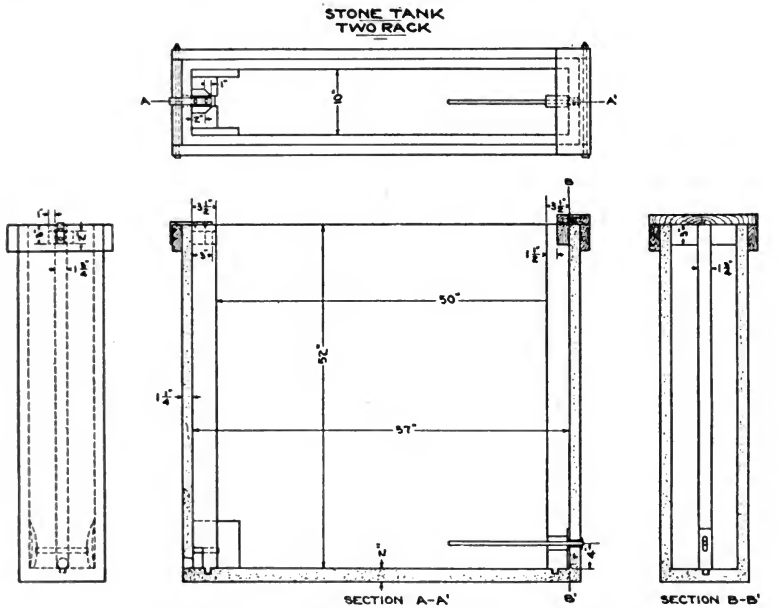

FIG. 3. Stone developing tank with rack guides.

At the top of the tank it is kept well away from the side of the tank by reason of the location of the locking ledge at the front which extends only a short distance from the center guide. At the back of the tank the rack end is held under a ledge from which it is released when the rack is drawn toward the front end preparatory to lifting it out. The upright ends of the rack extend farther beyond the cross bar at the upper end of the rack than at the bottom so that the film is always well below the surface of the liquid when the ends of the uprights are held under the ledges.

Rack Light Lock.—Where space is limited the usual types of light lock for passing racks of wet film to the light room from a very dark room are not possible. Fig. 4 shows schematically a rack light lock which occupies only the same floor space as a single rack tank. The doors are stepped so as to provide complete light locking and are hinged on the side so that they can be opened and closed very quickly and require a minimum of space. When either door is closed it releases the two locks holding the other. A spring hinge opens the door as soon as it is released but the door is stopped by a safety catch when

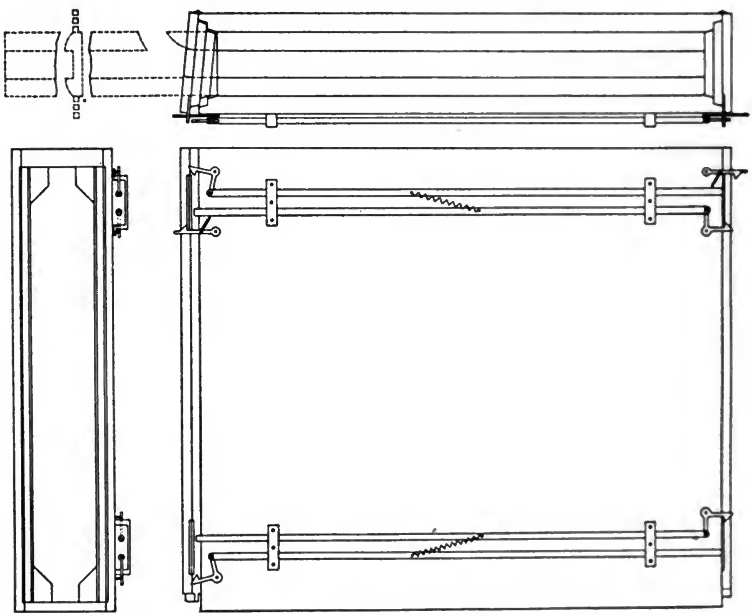

FIG. 4. Light lock for developing racks.

it is free of the lock at a point about 1 inch from the jamb. When a rack is to be passed the operator releases the catch, allowing the door to open wide.

The inside of the light lock is fitted with a guide track for the rack at top and bottom. The lower guide is continued in the floor about one rack length outside the light lock, to assist in directing the rack properly in the darkness. A safelight illuminates the interior of the light lock and the extension of the lower guide.

Waterproof Hand Lamp.—For use in the developing room an ordi-

nary type of flashlight is too easily damaged by liquids to be dependable. Either the switch fails, the dry cells are damaged, or the safelight filters are injured within a short time after it becomes wet.

A safe hand light has been designed which will not be damaged by continual immersion in water or developer. As shown in Fig. 5, the lamp consists of a monel metal tube closed at either end by caps fitted with soft rubber gaskets. The dry-cells, switch, and lamp are enclosed within this seal and the safelight glass is held against the gasket in one cap. The lamp is screwed into a reflector of the usual type and is electrically connected with the battery in the ordinary manner except that the switch is of the mercury type which closes the circuit when it occupies a certain position. The choice of a switch of this

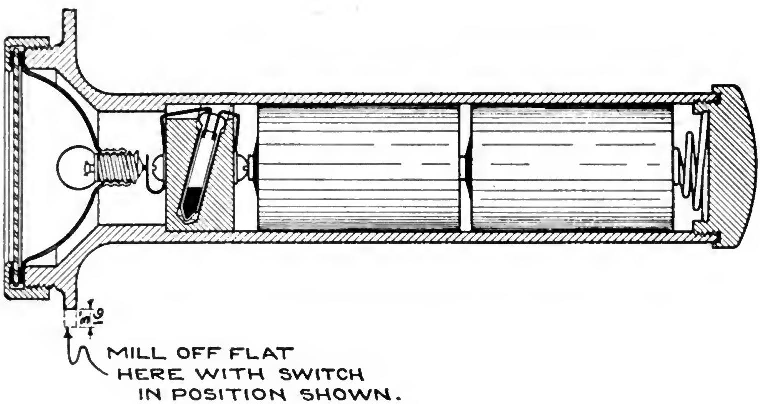

FIG. 5. Waterproof flashlight.

type eliminates the need for lever or sliding parts extending to the outside of the tube.

A switch of the type indicated, when mounted as shown in the figure, opens the electrical circuit when the lamp rests in a vertical position on the wide end or when allowed to come to rest on its side. The flange just back of the safelight is eccentric and is provided with a flat spot at the lowest position so that if it is laid down on its side it rolls to a point where the current is switched off. To obtain light, the lamp is turned in the hand until the circuit is closed.

Glove Cleaning Equipment.—Very serious trouble in the form of spots or streaks on the film can result from contamination by chemicals carried on the hands or gloves in the developing room. If no other provision is made it is necessary for the operator to attempt

rinsing gloves in a film washing tank, usually with poor results and considerable hazard to the contents of that tank. The use of a faucet is slow. The equipment shown in Fig. 6 makes the rinsing operation easy, quick, and effective.

Two lengths of metal tubing were drilled with $^1/_{16}$-inch holes and bent to the form shown in the figure, so that a glove held within the loop can be rinsed by streams from all sides at once. The washers are very convenient when mounted as shown with guards to confine the spray. Superstainless steel was used in the construction so that the

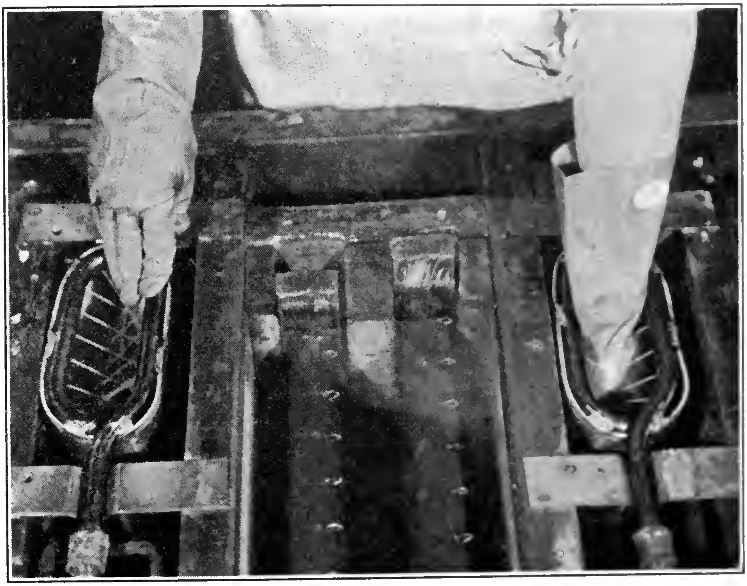

FIG. 6. Spray washer for cleaning gloves.

rinsing equipment could not of itself be a source of contamination as a result of corrosion. The water is controlled by a pedal valve so that the gloves are not polluted again in shutting off the water.

If it becomes necessary for a developing room man to handle alternately racks carrying wet and dry film, the gloves must be dried effectively before he takes a dry rack otherwise the film is very likely to be spattered. Wiping with a towel is not satisfactory because even with great care, water often remains between the fingers in drops which are thrown off when the hand comes to a stop suddenly in grasping the rack.

This wiping can be done effectively by means of a compressed-air "brush" which consists of a straight length of metal pipe or tubing drilled with small holes somewhat similar to that described above for rinsing. With a supply of filtered compressed air at a pressure of 10 pounds or more the gloves will be entirely free of water after about two passages in front of the blast of air from the small holes. The water is knocked off by the force of the air so that the action is very rapid. In this case the pipe should not be bent into a closed loop because water is likely to remain on the metalwork and be picked up by the dry glove as it is withdrawn. A pedal valve is most convenient for controlling the compressed air.

Goggles.—Between 20 and 30 minutes are required for practically complete adaptation of the eyes of a person entering a room lighted in a way that is safe for panchromatic film after being in daylight or a well lighted room. This adaptation is lost in a few moments if he returns to a brightly lighted room after which it is necessary to go through the long process of adaptation again. It is helpful to those in a laboratory who are required to pass to and from such darkrooms to use dark goggles while in the light room so that the eyes remain adapted to the darkened condition. The visual density of the goggles should be about 3.0, which is about the least that can be used without allowing serious change in adaptation level. A more dense glass reduces the visibility excessively in the light room. This figure is relative to the conditions encountered but can be understood to apply to good artificial illumination and a typical panchromatic darkroom where indirect lighting is used. Very cheap goggles of the kind supplied with "health" lamps can be obtained from the manufacturers of goggles. The glass referred to is designated by their number 10.

PRINTING EQUIPMENT

Balance Wheel for Continuous Printer.—In a continuous printer the negative and positive films must be drawn past the printing aperture at a constant speed so that irregularities will not be introduced into the picture or sound prints as a result of variations in the time of exposure. Irregularities of motion of the same magnitude may be tolerable in a step printer if their frequency of occurrence is very much greater than the time required for printing one frame and if they sum up to produce a substantially constant total time of exposure for every frame. In a continuous printer, if the motion of the film is retarded or accelerated momentarily, the part passing the printing

aperture will receive more or less exposure than adjacent parts. These variations due to mechanical irregularities in the driving mechanism often occur several times while a single frame is passing the aperture and are frequently of such magnitude as to produce very objectionable cross lines in the print.

This irregularity can be corrected by using a constant-speed motor and by protecting the sprocket shaft from influences which tend to produce momentary departures from continuous motion. The best device for the purpose is a flywheel used in combination with a vibration-absorbing drive coupling[2] by means of which unevenness of motion in the drive train is minimized.

In an installation of a flywheel in a continuous printer the original shaft was replaced by a longer one capable of carrying the flywheel, as shown in Fig. 7, and was supported by an outbearing installed for the purpose. The sprocket was attached by a rigid coupling at the end of this new shaft. Beyond the outbearing a single bearing was installed to carry a driving shaft. At one end this driving shaft is connected to the gate sprocket shaft by a vibration-absorbing coupling consisting of a short piece of rubber hose, and at the other end it carries a pulley. Power is transmitted to this pulley by a belt from the speed reduction at the motor.

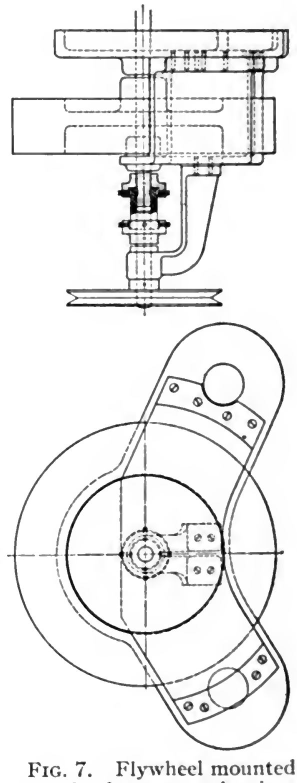

FIG. 7. Flywheel mounted on shaft of gate sprocket in a continuous printer.

The feed and take-up sprockets in this printer are geared directly to the shaft of the gate sprocket. Unless the moment of rotation of the gate sprocket assembly could be made very great it was feared that unevenness in motion might result from the reaction of the drive gears of the other sprockets. A 30-pound flywheel, proportioned as shown in Fig. 7, was chosen.

The printer was tested carefully by making a flash exposure on a strip of motion picture positive film while the lamp intensity was held constant. It was found that the flywheel had overcome the

unevenness of motion of the film at the gate. This test also confirmed the opinion that any tendency toward unevenness caused by the other sprocket drives was overcome by the large moment of the flywheel.

Light Change Rheostat for Lamps of Different Power.—Light change units have been produced by means of which negatives requiring a large number of light changes can be made without resetting. Such devices, if portable, can be used with any printer when the nature of the work requires it.

FIG. 8. Rewind with weighted roller for winding a firm roll.

In some laboratories different types of printer are used in which lamps of different power are required by the differences in time of exposure. It is desirable that the exposures given by the two types of printer be equal for corresponding light control steps so that the scene charts can be used interchangeably. Therefore the portable light change unit must be equipped with two rheostats, one for each type of lamp, and a means for switching from one to the other.

A unit of this kind has been equipped to give 17 equal exposure

steps with either a 60-watt, 120-volt lamp with S-1 cage filament, or a 250-watt, 120-volt projection monoplane filament lamp.

Two resistances were constructed by winding a wire of low temperature coefficient of resistance on pipe clay cylinders. Brass clamps were slipped over the rheostat to permit tapping off the various steps of resistance required. Clay supports of the same size were used for the two rheostats but allowance was made in the choice of wire size and the closeness of winding to provide the necessary resistance and for the dissipation of heat. Lead-in wires were carried from the clamps to an 18-pole, double-throw switch, by means of which the several bus-bars in the selector panel could be connected to the several taps of the 60-watt or 250-watt rheostat, respectively. A sliding contact type of switch was used although an enclosed mercury switch, while rather expensive, would be preferable in most cases because it requires less attention.

The 60-watt lamp was used in a printer equipped with a light control designed to give a range of intensity of 1.0 to 100.0 in equal logarithmic steps. The necessary lamp current values had been calculated by means of the lamp data and formulas given[3] by C. Tuttle, and are shown in Table I. The printer in which the 250-watt lamp was to be used was equipped with a manually controlled diaphragm light change.

TABLE I

Step Relationship for 60-Watt Lamp, S-1 Cage Filament

Step Number	Log I (Relative)	Log C	C (Calc.)
1	0.0	$\bar{1}.4471$	0.280
2	0.1176	$\bar{1}.4594$	0.288
3	0.2352	$\bar{1}.4718$	0.296
4	0.3528	$\bar{1}.4841$	0.305
5	0.4704	$\bar{1}.4965$	0.314
6	0.5880	$\bar{1}.5100$	0.324
7	0.7056	$\bar{1}.5212$	0.332
8	0.8232	$\bar{1}.5345$	0.342
9	0.9408	$\bar{1}.5458$	0.351
10	1.0584	$\bar{1}.5582$	0.362
11	1.1760	$\bar{1}.5706$	0.372
12	1.2936	$\bar{1}.5833$	0.383
13	1.4112	$\bar{1}.5954$	0.394
14	1.5288	$\bar{1}.6066$	0.404
15	1.6464	$\bar{1}.6190$	0.416
16	1.7640	$\bar{1}.6323$	0.429
17	1.8816	$\bar{1}.6447$	0.441
18	2.0	$\bar{1}.6571$	0.454

Since the relative illumination efficiencies of the optical systems in the two printers were not known, it was necessary to determine by photographic tests a set of conditions under which exactly equal exposures were given, and then from the data, to calculate the lamp current values at which the other exposures would be obtained.

It was found that when the 250-watt lamp was operated at 101.9 volts in the printer where it was to be used an exposure was given which was equal to that given in the other printer by the 60-watt lamp operated at 106 volts. The expression for the current-voltage relation, as given by Tuttle, is

$$V = aC^b$$

where C is the current in amperes, V is the voltage, and a and b are constants. The current flowing, when the voltage drop across the 250-watt lamp was 101.9 volts, was calculated and found to be 2.132 amperes. The formula given by Tuttle relating the lamp current with the intensity is as follows, M, K, a, and b being constants:

$$\log I = \frac{(b + 1) \log C + \log a - \log K}{M} \tag{1}$$

or transposed:

$$\log C = \frac{M \log I + \log K - \log a}{b + 1} \tag{2}$$

By substituting the values of M, K, a and b, for the 250-watt lamp this equation reduces to

$$\log C = 0.807 \log I + 0.0204 \tag{2a}$$

The actual intensity is not known, but instead, that given when the lamp current is 2.132 amperes is considered as having the relative value of 100. It was therefore considered desirable to modify the constant term in equation (2a) to agree with this value. Accordingly the logarithm of 100, or 2.0, and the logarithm of the current, 2.132 amperes, or 0.3287, were substituted in the equation in the form

$$\log C = 0.807 \log I + k$$
$$0.3287 = 0.807 \times 2.0 + k$$

which gave a value for

$$k = -1.285$$

Now, it was necessary to calculate, by means of the equation containing this new constant and having the form

$$\log C = 0.807 \log I - 1.285, \tag{2b}$$

seventeen other values of lamp current corresponding to 17 steps in lamp intensity, each differing from the next by an equal logarithmic difference. Since the total change in 17 steps is as 100 to 1.0 of which ratio the logarithm is 2.0, then each log intensity step has a value of

$$\frac{2.0}{17.0} = 0.1176$$

The values of log I and log C for the 250-watt lamp are shown in Table II.

TABLE II

Step Relationship for 250-Watt Lamp

Step Number	Log I (Relative)	Log C	C (Calc.)
1	0.0	0.1672	1.470
2	0.1176	0.1767	1.502
3	0.2352	0.1862	1.535
4	0.3528	0.1957	1.569
5	0.4704	0.2052	1.604
6	0.5880	0.2147	1.640
7	0.7056	0.2242	1.676
8	0.8232	0.2337	1.713
9	0.9408	0.2432	1.751
10	1.0584	0.2527	1.789
11	1.1760	0.2622	1.829
12	1.2936	0.2717	1.869
13	1.4112	0.2812	1.911
14	1.5288	0.2907	1.953
15	1.6464	0.3002	1.996
16	1.7640	0.3097	2.040
17	1.8816	0.3192	2.085
18	2.0	0.3287	2.132

As an alternative to these calculations a graphical method could have been used, plotting log C against log I. In his paper Tuttle gives a number of corresponding values for intensity and lamp current.

By using an ammeter in series with the lamp and light change unit the resistance taps were adjusted to give the required lamp current at each light change step with the line voltage constant. Each rheostat was adjusted in this manner while connected to its proper lamp.

In another instance it became necessary to use a lamp for which data were not available. The photographic characteristics of the lamp were determined as follows: A uniform density step tablet on motion picture film was chosen for the measurements. For the most dependable results the tablet should have density steps of approximately 0.15 from zero to 3.0 and should be developed in a developer

which produces a silver image having no color selectivity of light absorption. If the developer contains no other developing agent than elon this condition can be obtained. With a tablet of this character it is not necessary to make any correction of the visual density.

A number of prints are made from the tablet on motion picture positive film with the lamp to be measured in the printer. In each successive print the lamp current or voltage is varied in a definite manner so as to cover the range of intensity found necessary in previous trials. The number of exposures made should be about equal

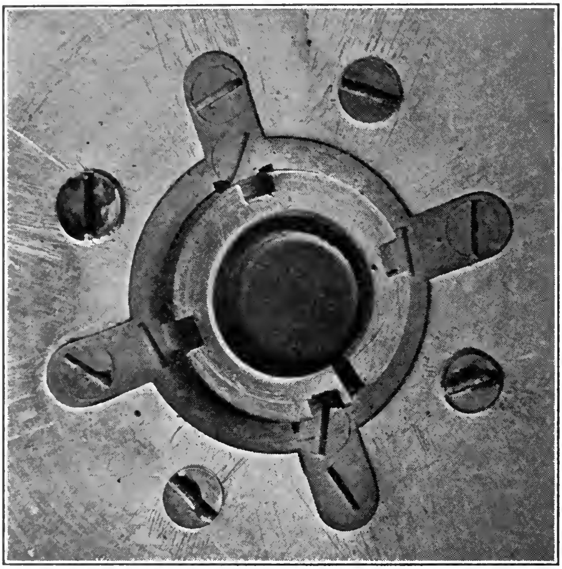

FIG. 9. Disk rewind close-up showing stripper fingers for facilitating removal of wound roll.

to the number of steps which will be used, say, 15 or 20. These prints from the step tablet are developed together, great care being taken to assure uniformity, for a time sufficient to produce a gamma of at least 1.0. The densities are read and plotted, on a single sheet of paper, against the densities of the tablet from which they were printed. A number of characteristic curves are produced which have the same slope but which are separated from each other along the tablet density axis. These displacements are taken as a measure of the log exposure differences for different lamp currents. By reading the position of the

curves along the scale of tablet densities in the reversed direction, relative values for log intensity of exposure corresponding to the values for lamp current used in the tests are obtained. If these values for relative log intensity are plotted against the logarithm of the lamp current a straight line is obtained from which lamp current values for any lamp intensity step relationship can be chosen. Also, if desired, the lamp constants can be determined for use in the formula.

FIG. 10. Transportable and collapsible winding core of 2-inch diameter.

It is well, before using the available data, to check the electrical characteristics of a representative group of the lamps at hand. This check will usually be sufficient to detect changes made from time to time by the manufacturers. If the electrical characteristics change appreciably, it is advisable to make new photometric measurements as described above.

REWINDING EQUIPMENT

Film Roll Winder.—A large proportion of the surface injury to film is a result of cinching which occurs during winding. It is especially

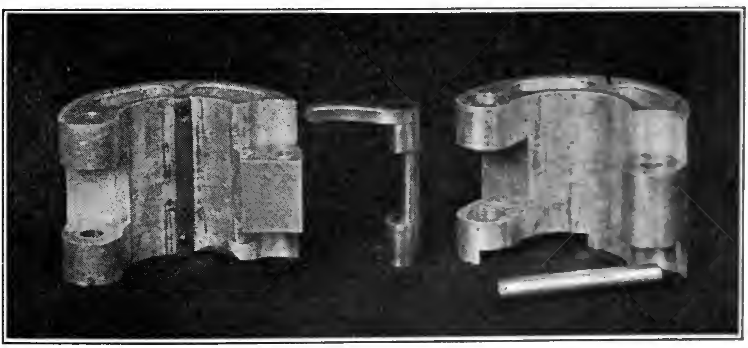

FIG. 11. Parts for assembly of portable winding core.

desirable, therefore, to wind negative film in such a way as to make firm rolls which will not be cinched on subsequent rewinding. A good

method of securing tightly wound rolls is to allow an idle roller to ride on top of the winding roll. In this way the film is pressed against the roll by a force applied perpendicularly to the direction in which the film travels so that there is no danger of cinching. Fig. 8 shows a winder of this type with a guide roller at the lower left. Both rollers are undercut so that they bear on the film only near the edges.

Stripper Fingers on Disk Rewind.—Trouble is experienced frequently when it is attempted to eject a roll of film from the core of a

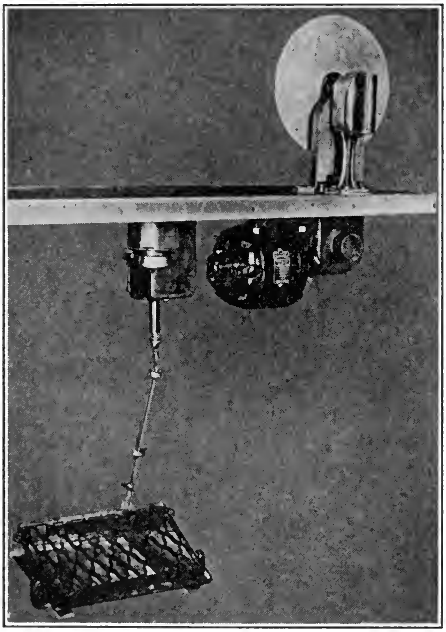

FIG. 12. Motor-driven rewind with speed-control pedal.

disk rewind by means of the disk. This is more commonly found with rewinds which have become worn so that there is excess clearance between the disk and core. When the disk is moved, one convolution of film slips into the space around the core and the disk becomes jammed. This difficulty is overcome in a type of core (Fig. 9) which is slotted to admit four stripper fingers attached to the face of the disk. These fingers prevent the film from slipping between the disk and core. This trouble is avoided also if the film is wound on a portable core such as that described in the section below.

Large Winding Core.—Cinching is usually worse near the ends of rolls which have been wound on very small cores. In Fig. 10 is shown a portable aluminum core 2 inches in diameter by means of which the treatment of the film during winding is improved. The core is slipped over the special core described above or an ordinary 1-inch hub modified by increasing the width of the slot to admit the key

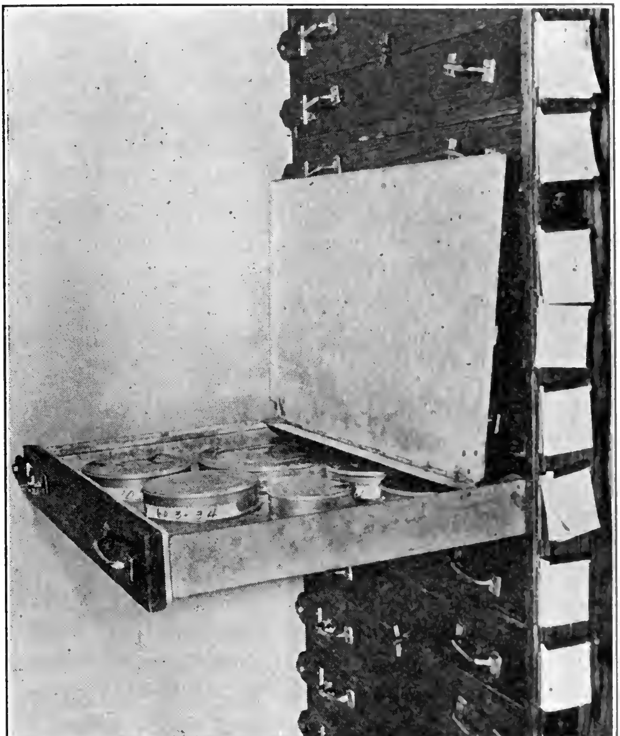

FIG. 13. Close-up view of drawer of valuable film storage cabinet.

which is built into the core. The core is collapsed for removal when the roll is to be stored or shipped out of the laboratory by moving the small lever seen in the top surface in Fig. 10. A novel means is used for preventing the film from slipping on the core, which consists of a thin piece of soft rubber cemented in a slot in the core. When the film is wound tightly around the core it presses against the rubber, which protrudes about $^1/_{32}$ inch. When the core is collapsed for

removal from the film, the rubber is no longer in tight contact and the core can be slipped out easily without the film adhering. The core is composed of two pieces of aluminum, three pieces of steel, and two screws. The parts are illustrated in Fig. 11. In this figure can be seen the eccentric pin by which the expansion of the core is positively effected.

Motor Driven Rewind.—In winding operations where it is necessary for the operator to have both hands free for the work, an electrically driven rewind is helpful. This applies particularly to cleaning, where it is preferable not to have to stop frequently to apply cleaning solvent to the cloth. Fig. 12 shows a rewind driven by a variable-speed motor. The controller, operated by a pedal, gives a choice of speeds which covers the range required by the varying diameter of the roll. It would be possible to make the film travel at a constant speed by allowing a roller riding on the winding roll to vary the speed of the motor continuously.

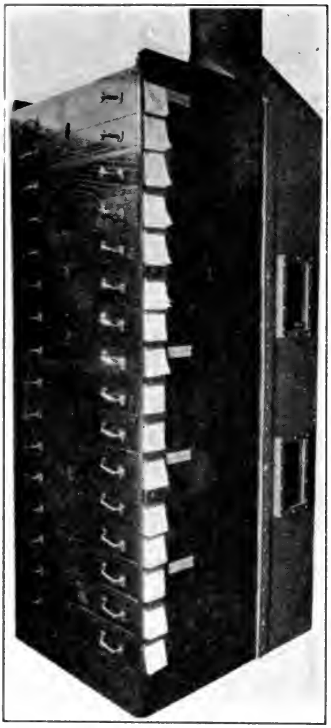

FIG. 14. Overnight storage cabinet for valuable film.

FILM STORAGE

The storage cabinet described in a previous communication[4] was designed for permanent storage and does not lend itself readily to the needs of the cutting room, where it is necessary to put away for short periods of time pieces of valuable film of various lengths. A slightly modified type of cabinet has been designed, which permits more convenient inspection of the contents of each drawer. As shown in Fig. 13, the drawer is somewhat larger than in the type intended for permanent storage and has a hinged cover which can be raised after the drawer is drawn partly out of the cabinet. This cover, which must be closed completely before the drawer can be pushed back in place, has a rim which enters into a close fitting well

so as to make a tight closure. Near the back of the drawer but inside of the fire flap is a coarse wire screen to prevent the film cans from being pushed out into the flue when other cans are put in near the front. In Fig. 14 the cabinet is shown as it stands in a vault.

Acknowledgment is due to various members of the Research Laboratory and Development Department who gave counsel and suggestions in the design of the equipment described.

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CAREER OF L. A. A. LE PRINCE*

E. KILBURN SCOTT**

Summary.—In November, 1886, Le Prince, an inventor and scientist living in New York, N. Y., applied for a U. S. patent covering a photographic camera which would expose successively a number of images of the same object or objects in motion and reproduce the same in the order of taking. Although the patent granted him on January 10, 1888 (U. S. Pat. 376,247), described a camera having sixteen lenses, it is shown that the original application specified "one or more lenses." His British patent No. 423, accepted Nov. 16, 1888, provided for both a camera and projector with one lens as well as multiple lenses. Most of Le Prince's important work was done in England and France from 1887 to 1890 with a single-lens camera, at least two of which were built and used. Descriptions are included of these cameras as well as a multiple lens camera. Evidence is introduced concerning the design of the cameras, such as the use of the Maltese cross intermittent movement, and of the building of and demonstrations with a projector.

Louis Aimé Augustin Le Prince was born 89 years ago (Fig. 1). His father was a major of artillery in the French Army, an officer of the Legion of Honor, and was an intimate friend of Daguerre, the famous pioneer of photography, who gave his son some early lessons in the art.

Le Prince was educated in colleges at Bourges and Paris and did post-graduate work in chemistry at Leipsic University, which was very useful for his future career. He was a born artist, and, after some training in Paris, took up oil painting and pastel portraits; he also specialized in the painting and firing of art pottery.

In 1866, he met a friend, John R. Whitley, who afterward became famous as the builder and organizer of the first exhibitions at Earl's Court, and also as the builder of Le Touquet in France. He invited him to Leeds, and Le Prince decided to remain and join the firm of Whitley Partners, brass founders, of Hunslet, as designer, afterward taking charge of the valve department.

In 1869 he married Miss Whitley, who had been trained as an artist under Carrier Belleuse, the director of the Government pottery of

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** Consulting Engineer, London, England.

Sèvres. His father-in-law, Joseph Whitley, was a remarkably clever inventor, who introduced, among other things, the method of spinning large cylinders and pipes from molten metal.

During the Franco-Prussian War, as an officer of volunteers, Le Prince went through the siege of Paris. After returning to Leeds, he and Mrs. Le Prince started a school of applied art in Park Square, the first of its kind in Leeds.

Le Prince carried out color photography on metal and pottery and fixed the colors in a special kiln. He executed commissions for Royalty, and his portraits of Queen Victoria and W. E. Gladstone were

FIG. 1. Louis Aimé Augustin Le Prince.

placed in the foundation stone of Cleopatra's Needle, along with other records of the time.

In 1875 the series of photographs taken by Eadweard Muybridge at Palo Alto, Calif., were published, and Le Prince was attracted to the idea of producing a series of photographs, in other words, "motion pictures" with one camera. Muybridge employed about two dozen separate cameras, and his mode of taking the photographs in sequence was limited and not suitable for reproducing the illusion of motion.

Le Prince had been working at this for some time, when, in 1881, his brother-in-law, who had become interested in the Lincrusta-Walton process, invited him to go to New York to assist in introducing that process. He went, and, on the patent rights being sold to an American company, had to find something else to do.

Mrs. Le Prince and the family had joined him meanwhile and deciding to stay on, he became manager of a group of French artists who produced large circular panoramas. One in New York showed the battle between the *Monitor* and the *Merrimac*. Others were in Washington and Chicago.

Jean Le Roy, of New York, who was employed by Joseph T. Thwaites, the English photographer, from 1872 to 1879 and from 1882 to 1888, has written as follows:

"I met and became acquainted with Le Prince about the spring of 1884, when he came to my employer's studio and photograph gallery at No. 1 Chambers Street, New York City. I recollect an order was for a number of lantern slides of military scenes, that he explained were to be made to scale so that he would be able to project them without any varying sizes or proportions. It was to help him to make outline drawings on canvas to be used in a panorama of war. This was built at 59th St. and Lexington Ave., in later years converted into the 71st Regt. Armory, and now the site of the Plaza Theater. The last time I saw Le Prince was in 1887."

At this time, Mrs. Le Prince was teaching art at the Institute for the Deaf on Washington Heights, New York, N. Y. Her husband became friendly with the principal, Isaac Lewis Peet, and was permitted to use the tools and facilities of the institution's well-equipped workshop. Joseph Banks, the mechanic, who is still living in New York, assisted Le Prince in the constructional work and recalls the early attempts to make motion picture machines.

When a child of 14, Miss M. Le Prince went one evening to the institute. Seeing a light shining under the door, she entered and saw her father and Joseph Banks operating a machine which threw dim outlines of figures on the whitewashed wall. Thus the first projected motion pictures of Le Prince—the earliest in America—were screened in the Institute for the Deaf.

In 1886 Le Prince drew up a specification giving full details and working drawings, and applied for an American patent in November of that year. Three clauses of the application read as follows:

(1) The successive production by means of a photographic camera of a number of images of the same object or objects in motion and reproducing the same in the order of taking by means of a "projector" or "deliverer," thereby

producing on the eye of the spectator a similar impression to that which would have been produced by the original object or objects in motion.

(2) In an apparatus for producing "animated" pictures the continuous alternate operation of the film and its corresponding shutter or series of shutters.

(4) As a means of producing "animated" pictures on a photographic receiver provided with one or more lenses and one or more shutters, in combination with one or more intermittently operated film drums.

Being a good mechanical draughtsman, he made his own drawings for the specification and showed the most difficult proposition, namely, a machine with 16 lenses. It is important, however, to note that his specification, as first filed, covered any number of lenses from one upward.

On January 10, 1888, the U. S. Patent Office in Washington granted his patent, No. 376,247, entitled "Method of, and Apparatus for, Producing Animated Pictures." They, however, cut out claims for machines with one lens and with two lenses, giving as the reason that Dumont's British patent No. 1457 of 1861 was an interference.

Le Prince was in England at the time and did not know that this had been done until it was too late for effectual protest. His patent attorneys, Munn and Co., very foolishly permitted the patent to be issued without challenge, and so it stands in the American records.

Many consider the attitude of the Patent Office to have been wrong because the Dumont patent was in no sense a motion picture device. It was for photographs on glass plates, arranged to form the facets of a prismatic drum, the object being to enable one to choose the best single photograph out of several successive ones. Dumont's object was not to show continuous movement by projecting pictures on a screen, which was the purpose of Le Prince.

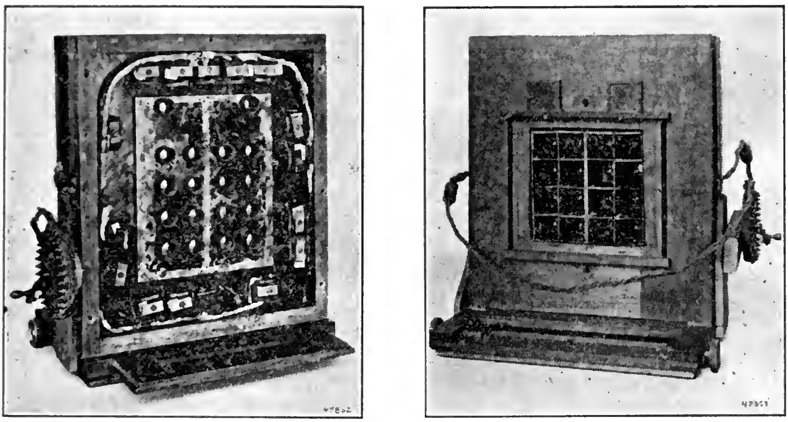
In a statement of his father's claims, made in 1898, Adolphe Le Prince wrote quite fairly that:

"He was the first investigator to grasp the value and necessity of an unlimited amount of pliable film, moving from a *supply* drum, on which it was *wound* as many times as desired; not just a circumference length as Dumont had in mind. In the Le Prince apparatus the part of the film acted on was, at that instant, *between* the upper and lower drums, and therefore *flat*, being additionally aided by a clamping pad and tension device; this enables the Le Prince apparatus to take large pictures, and yet have perfect focus; both these points are *primary necessities* for good projection of 'Animated Pictures' on a screen.

"Marey, in 1885–1886, working independently on somewhat the same lines as my father, added greatly to the understanding of 'Animal Locomotion' and its more specific allies, but he had not used an endless pliable film, nor a means for definitely cutting off one phase from the next. His work has been given the credit it deserves."

Miss M. Le Prince, who saw pictures which her father took between 1885 and 1887, and which he projected on a wall of the Institute for the Deaf, has stated that some were taken with a single-lens camera-projector, and others with a four-lens camera. The pictures were about $1^1/_2$ inches in diameter.

It is important to note that his British patent No. 423, applied for on the date of the issuance of his American patent, January 10, 1888, and accepted November 16, 1888, provided for a "receiver" (camera) and "deliverer" (projector) with one lens as well as multiple lenses. Otherwise it differs in no other essential particular from his United States patent.



Front view. Rear view.

FIG. 2. Le Prince 16-lens camera.
(Reproduced by courtesy of the Science Museum, London.)

Later, similar patents were issued by France, Italy, Austria, and Belgium, without the Dumont patent or any other being cited against them.

Obviously, if a machine could be designed and made to work with 16 lenses, it was easier to make it with 8 or 4, and easiest of all with only one. We do know that practically all Le Prince's most important work was done with one-lens machines. The camera which Le Prince made in Leeds in 1887–1888 had only one lens, as Mr. Frederic Mason (who helped to make it) and myself have repeatedly stated. (See appendix.) This is fully demonstrated by the actual machine now in the Science Museum, London.

Le Prince returned to England in May, 1887, and then stayed with his mother in Paris. While there he gave attention to the taking out of his French and other continental patents. To facilitate this and demonstrate "proof of working," as it is called, he made a camera-projector with 16 lenses (Fig. 2).

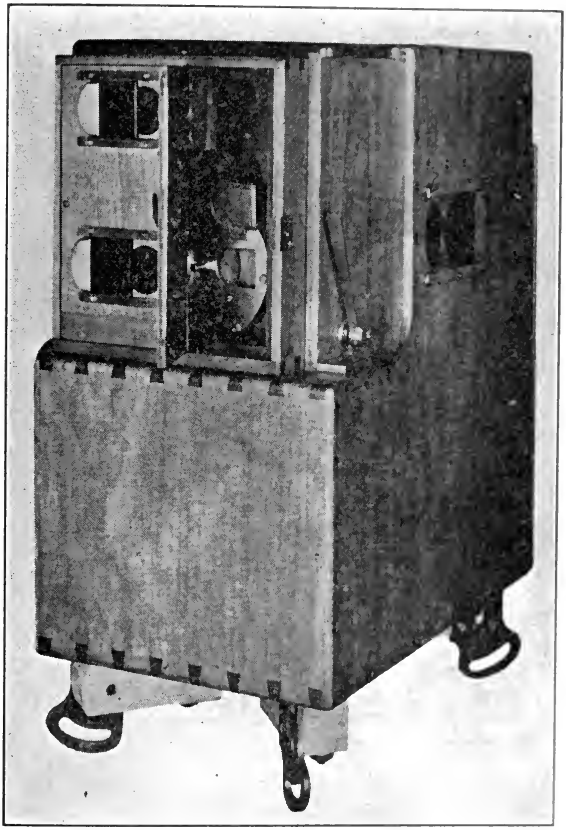


FIG. 3. Le Prince single-lens camera; 1888 (front). (Reproduced by courtesy of the Science Museum, London, England.)

The particular model brought from New York by Miss Le Prince is now in the Science Museum. It is constructed to take two bands of film of sensitized gelatin, mounted side by side on rollers in a chamber attached to the back of the camera. Of the sixteen lenses, eight

facing one film were released in rapid succession, after which the remaining eight lenses were discharged while the first film was being moved on ready for another set of pictures. Each film was clamped during exposure by a frame operated by a cam.

The lenses were operated by an ingenious system of double shutters

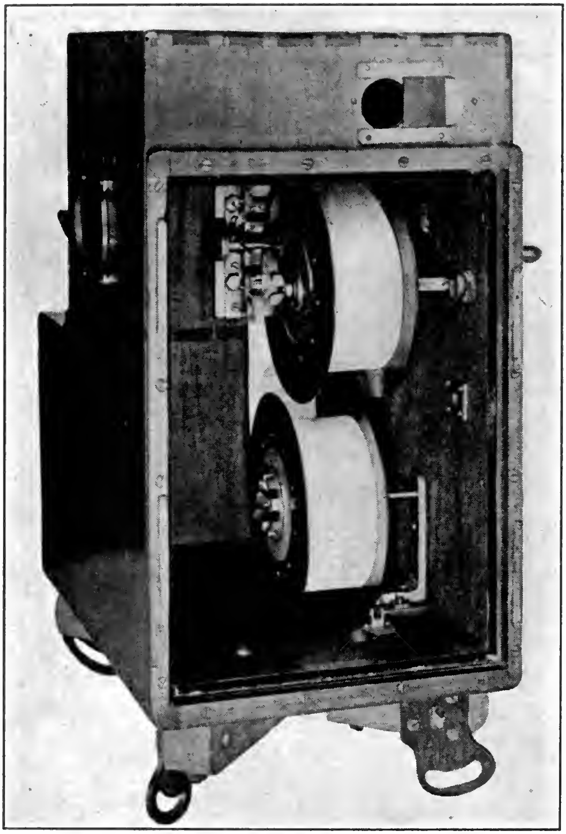


FIG. 4. Le Prince single-lens camera; 1888 (interior). (Reproduced by courtesy of the Science Museum, London, England.)

worked by a series of electromagnets connected to a battery and a circular electric switch. On rotating the handle of the switch, the shutters operated in regular and rapid succession. Two additional lenses were provided as view finders, one for each film, in con-

junction with a bellows placed at the back of the apparatus; focusing could be done while the machine was working.

Several sets of motion pictures were taken, including one of the mechanic who assisted Le Prince to make the machine. They were projected on a screen in the Paris Opera House on March 30, 1890. The Secretary of the National Opera made a statement, of which the following is a translation:

"I, the undersigned, Ferdinand Mobisson, Secretary of the National Opera, Paris, residing at 38 Rue de Mauberge, certify by this present to have been charged with the study (or examination) by means of the apparatus brought before me, of the system of projection of animated pictures, for which Mons. Le Prince, Louis Aimé Augustin, of New York, United States, has taken out in France patent rights dated the 11th of January, 1888, having the number 188,089, for 'Method and Apparatus for the projection of Animated Pictures, in view of the adaptation to Operatic Scenes,' and to have made a complete study of this system.

"In faith of which, I have delivered the present certificate to serve whom it may concern.

"Paris, March 30th, 1890.

"(Signed) F. MOBISSON."

Before going to Paris he had been to see William Mason and Son, woodworkers, of 150 Woodhouse Lane, Leeds, and secured the services of Frederic Mason to make parts of cameras, *etc.* On returning to Leeds, he rented a workshop at 160 Woodhouse Lane, and employed as assistant a clever mechanic, James W. Longley, who had done work for him at Rhodes Bros., Engineers, of Leeds. Some of the metal work was also carried out at Whitley Partners, his father-in-law being much interested in the invention. J. W. Longley was also an inventor, and made the first machines to deliver tickets automatically with coin-freeing mechanism. They were used at the Leamington athletic ground, Leeds.

By the summer of 1888, he had completed two cameras, each with a single lens, and (with the one also shown to The Royal Photographic Society and now in Science Museum) had photographed a series of pictures at the rate of 12 per second in the garden of his father-in-law at Roundhay. The following is a description of the camera (Fig. 3 and Fig. 4):

The film, $2^3/_8$ inches wide, is wound from one to the other of a pair of ebonite spools about six inches in diameter, one above the other. The top one is *revolved intermittently* by a cam bearing a number of teeth which engages with projections on the hub of the spool. The film is thus drawn up through the "gate" behind the lens in a series of

jerks. At each exposure, it is held fast by a flat brass plate also operated by a cam. The plate moves back slightly when the film is being pulled through, to prevent scratching. Many years later, this last device was claimed by firms as being original with them.

Light is cut off from the film during movement by a circular slotted brass shutter which revolves behind the lens in the same way as in modern machines. The shutter is a robust affair, and the opening in it is adjustable. Focusing is accomplished by means of a rack and pinion movement operated by a lever at the side, the front, bearing the lenses, and shutter being moved backward and forward. There is, of course, a finder lens attached above.

FIG. 5. Two Frames of a series taken by Le Prince, October, 1888.*

To assist in promoting smooth, even motion the spindle of the lower spool carries a heavy brass flywheel. The intermittent drive on the top spool was unvaried, whatever the amount of film the latter carried. Le Prince's assistant, James Longley, wrote:

"As the drum gets larger, it takes more material to go round. All we had to do was simply *rewind the band of pictures off the drums of the camera machine on to the drums of the delivering machine* and start the delivering machine with the same end of band of pictures. They would travel at the same rate in both the machines."

A series of pictures (Fig. 5) was taken by Le Prince in 1888 in the garden of his father-in-law, Joseph Whitley, at the residence now called Oakwood Grange, Roundhay, and occupied by Sir Edwin Airey, and the window shown in the photographs can still be seen. His son, Adolphe Le Prince, wrote the following on a print of these pictures:

"Portion of a series taken early in October, 1888, by the second one-lens camera. Le Prince's mother-in-law in this picture died October 24, 1888. Le

* This series was taken with a one-lens camera at rate of 10 to 12 images per second, in the garden of his father-in-law, Mr. Joseph Whitley, Roundhay, Hunslet, Leeds, England. Le Prince's son, Adolphe, and Mr. and Mrs. Whitley are shown in the picture, with a younger lady. The date is definitely determined because of the death a few days after of Mrs. Whitley. Le Prince cranked the camera and probably used gelatin or glass plates on the carrier in his camera, not having yet obtained celluloid film.

Prince's eldest son is also in the picture, as is his father-in-law. Taken from 10 to 12 a second. There was no trial of speed contemplated here."

The following statement was also made by him on prints of the series of pictures taken from a window of the premises of Hick Brothers, at the southeast corner of Leeds Bridge, which firm supplied Le Prince with tools and materials:

"Portion of a series taken by Le Prince with his second one-lens camera in October, 1888. A view of the moving traffic on Leeds Bridge, England, taken at 20 pictures a second in poor light. His eldest son was with him when he took the picture."

James W. Longley wrote about them in the following characteristic way:

"Leeds Bridge—where the tram horses were seen moving over it and all the other traffic as if you was on the bridge yourself. I could even see the smoke coming out of a man's pipe, who was lounging on the bridge. Mr. Augustin Le Prince was ready for exhibiting the above mentioned machine in public. We had got the machine perfect for delivering the pictures on the screen."

For taking these pictures, Le Prince used sensitized paper film, and one of the exhibits at the Science Museum is a reel of this material. It is on record that Le Prince used gelatin stripping film when Eastman introduced it. In any case he had no trouble in getting good photographs at 12 to 20 per second. The pictures of Leeds Bridge were on film $2^1/_8$ inches square.

To project the pictures on a screen was more difficult, for the reason that the film had to pass close to a lamp, and the heat made the material cockle or blister, and put the pictures out of focus.

His great problem was to obtain a suitable supporting base for his emulsion and, as mentioned in the specification, he tried horn, mica, hard gelatin sheets, and collodion sheets; also, at one time he used glass positives, attached to bands moved by sprocket wheels.

His patent specification refers to material carrying the film transparencies, reading:

"Punched with holes fitting on the pins of the guide rollers; also sensitive film for the negatives may be an endless sheet of insoluble gelatin, coated with bromide emulsion or any convenient, ready made, quick-acting paper."

His eldest son, Adolphe, who left a record of the experiments, stated that his father went to all the photographic supply houses in England, France, and the United States to obtain suitable material.

He obtained a supply of sensitized celluloid in sheets about a foot square, which he cut into positives and printed from the roll negative films. These he mounted on flexible, robust carrying bands.

Finally, the coming of long sensitized celluloid strip or film did away with the bands.

Evidence of his skill in making apparatus is well shown by the two large reels of celluloid, one of which is in the Museum (Fig. 6). They are of strips of celluloid 3 inches wide and about 12 inches long, cut from sheets and joined by pieces of silver. Two strips of silver along the edges are bent to form regular projections to keep the layers apart.

These particular reels were used for developing his exposed films, which were rolled up in the spool of celluloid, the whole being then immersed in the developer. The silver projections allowed space between each coil for the solution to reach the film. The celluloid

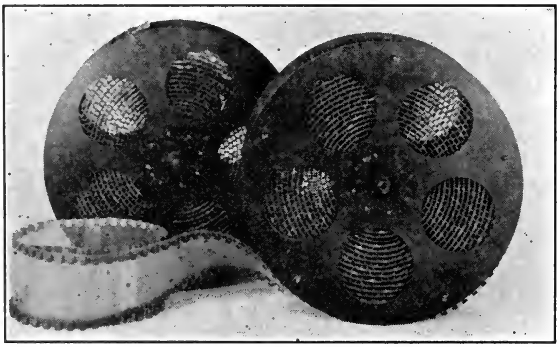


FIG. 6. Spools for developing film; Le Prince, 1888. (Reproduced by courtesy of the Science Museum, London, England.)

is pierced with holes to allow the developer free access to the film. The strip has a matte surface on one side. This idea was patented years later by another inventor, but if the authorities had known of Le Prince's arrangement they would not have allowed the patent.

Examination of the clever mechanism of the camera and the construction of the spools gives the impression that Le Prince had the ability to cope with all the problems necessary to make motion pictures a commercial success. Had he lived, he would have been a master figure in the industry.

He had the usual characteristics of the true inventor, and was always making improvements. His projectors or "deliverers" went through many stages with the object of simplifying the mechanism.

In the winter of 1888–1889 he built a "deliverer," or projector, having three lenses and three belts, which is thus described by his son:

"In this machine the belts, at slight tension, were moved by teeth pulling in the eyelets of the three belts, and rapidly stopping and starting at equal intervals (depending on speed of rotation of main shaft) by means of three 'pintooth' wheels timed to correspond with the opening and closing of the three lenses. The opening and closing were governed by a slotted circular shutter, rapidly rotating on a shaft. A gear wheel on the end of this shaft connected with the feed gear, and completed the harmonious action of the feed shutter and stopping and starting device. This deliverer gave continuous illumination on the screen.

"He also constructed in 1889 a one-lens deliverer, the picture belt being arranged in an endless spiral, the pictures appearing before the lens in rapid succession, and storing automatically as soon as projected and released."

A sketch made by his assistant, Longley, with descriptive letters, shows that the three-lens "deliverer" used the Maltese cross to give intermittent picture shift (Fig. 7). He says:

"g is the star wheel arrangement for allowing the band to work at the proper time. The wheel with the pins is for gearing into the band of pictures and should have two rows of pins, one on each side—and we had brass eyelets fixed in the band similar to the eyelets of boots."

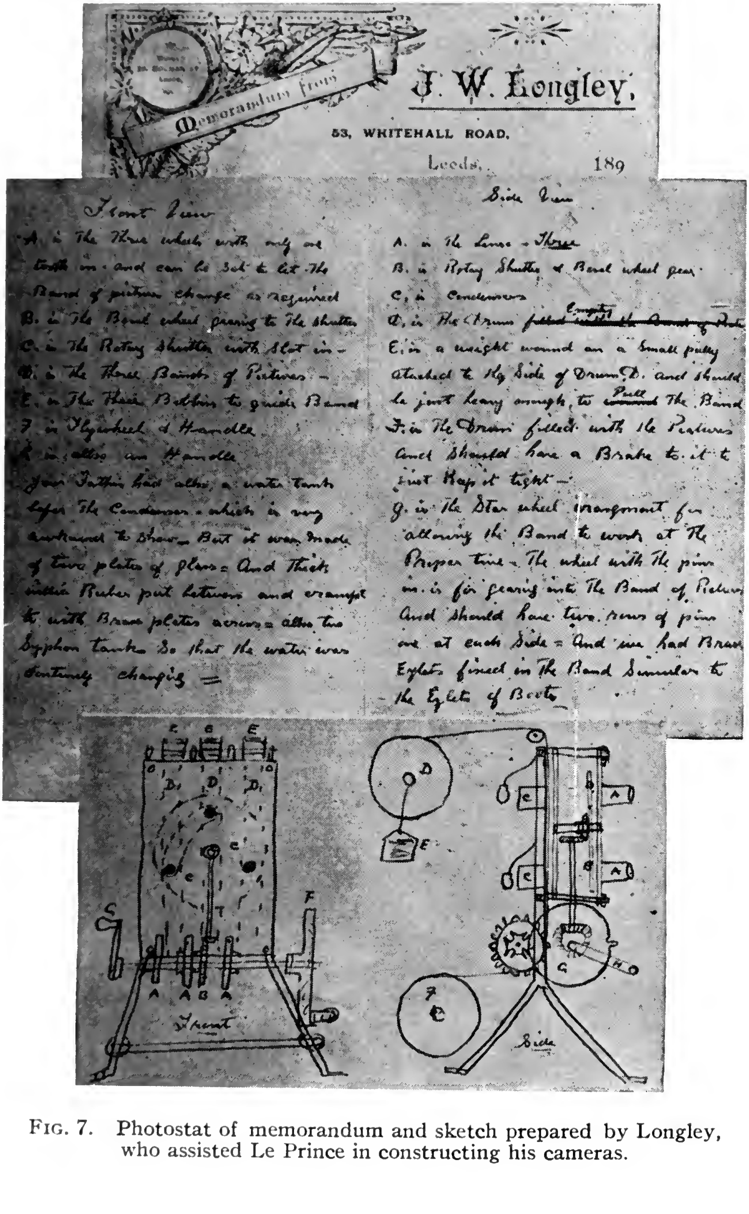
Being an artist, Le Prince appreciated the importance of color, and the patent specification he wrote in 1886 says:

"Once developed and toned the transparencies may pass through the hands of artists who will tint them in transparent colours, dyes, or lacquers as the subject may require."

In 1889, Le Prince constructed a projector to work with one lens, and decided to use an electric arc light instead of oxy-hydrogen previously employed. For this purpose, he came to his friend, Wilson Hartnell, an electrical engineer, of Leeds, by whom I was employed. I went to see about it and entering the workshop at 160 Woodhouse Lane, saw his assistant, Longley, whom I had known for some years. Noticing a large sheet at the end of the room, I asked if it was for a magic lantern, and his reply was, "Much better than that; the pictures actually move and represent life."

In due course, the plant was installed, direct current being generated by a Crompton dynamo driven by a semi-portable Robey boiler and engine in Mason's yard. That was at No. 150, and permission was obtained to carry the cables over intervening buildings to No. 160.

A difficulty in recording the history of events is that those who were eye-witnesses die. However, I state positively that the projector and the camera worked with single lenses, and William Mason and Wilson Hartnell have told me about seeing Le Prince's pictures on the screen.



Memorandum from

J. W. Longley,

53, WHITEHALL ROAD,

Leeds, 189

Front View

A is The Three wheels with only one tooth in - and can be set to let The Band of pictures change as required
B. is The Bevel wheel gearing to The shutter
C. is The Rotary shutter with slot in -
D. is The Three Bands of Pictures -
E. is The Three Bobbins to guide Band
F is Flywheel & Handle
G is also an Handle
Your Father had also a water tank before The Condenser - which is very awkward to show - But it was made of two plates of glass - And Thick india Rubber put between and cramped to with Brass plates across - also two Syphon tanks So that the water was continualy changing =

Side View

A. is the Lense - Three
B. is Rotary Shutter & Bevel wheel gear
C, is Condensers
D, is The Drum ~~filled with the Bands of Pictures~~ Empty
E, is a weight wound on a small pulley atached to the side of Drum D. and should be just heavy enough to ~~wind~~ Pull The Band
F. is The Drum filled with the Pictures And should have a Brake to it to just keep it tight -
G. is The Star wheel arrangment for allowing the Band to work at The Proper time - The wheel with The pins in. is for gearing into The Band of Pictures And should have two rows of pins one at each side = And we had Brass Eylets fixed in The Band similar to the Eylets of Boots

FIG. 7. Photostat of memorandum and sketch prepared by Longley, who assisted Le Prince in constructing his cameras.

The unveiling of a tablet on Le Prince's workshop (Dec. 12, 1930) has brought forward letters from people who would not otherwise have been traced. One from Walter Gee, chief engineer to the British Barnsley Co-operative Society, says:

"I am very pleased to give my testimony about the pioneer work of the late Louis A. A. Le Prince and confirm what I know of particulars given in your pamphlet about the electric installation.

"During the late eighties I was an electrician with Wilson Hartnell, M.I.Mech.E., Consulting Engineer, of Basinghall Street, Leeds, and worked on the installation for the supply of electricity to an arc lamp in Le Prince's workshop at 160 Woodhouse Lane, Leeds.

"Mr. Le Prince worked his projector machine and showed moving pictures on a white sheet hung at the other end of the room.

"At the time of the first switching on, there was one other person present beside Mr. Le Prince and myself, namely, James W. Longley, who was his assistant.

"I know nothing of details of construction of the projector machine, but I was very pleased to see it work so well. I noticed how Mr. Le Prince opened his mind as he was working it, for he had been very quiet up to then. . . .

"Regarding the time of the electrical installation, my recollection is that it was about the middle of 1889. In 1890, I came to Barnsley, to put in plants for the Barnsley British Co-operative Society, where I have been ever since and am chief engineer.

"(Signed) WALTER GEE."

J. T. Baron, chief electrical engineer of the Metropolitan Borough of St. Pancras, 57 Pratt Street, London, N.W.1, writes:

"I well remember the occasion of Mr. Le Prince's experiments about 1889 in Woodhouse Lane, when, along with others of Mr. Wilson Hartnell's staff, I was sent to see about fixing up the equipment, consisting of a dynamo and electric arc projector, for what was known to us then as moving pictures.

"I trust you will get further support for the interest you have taken in the recognition of Le Prince.

"(Signed) J. T. BARON."

Arthur Wood, engineer and machinist, of 331 Pietermaritz Street, Pietermaritzburg, Natal, wrote on the 25th of November, 1930:

"In 1888, two years prior to my leaving Leeds for South Africa, I was with the firm of Whitley Partners, Railway Works, Leeds. The head of the firm in those days was Mr. Joseph Whitley, a very capable man, one who would spend thousands of pounds in experiments for his business, and greatly interested in anything unusual.

"I can very well remember Le Prince's invention, as, while I was with Mr. Joseph Whitley, I personally made mechanical parts of the projector, such as the pedestal, gears, chains, *etc.* I was shown the film for which it was made,

and if my memory holds good this film was of a horse galloping, although I did not see it actually projected.

"(Signed) ARTHUR WOOD."

Certain people have said that Le Prince was not the pioneer he is claimed to be because he only made machines with multiple lenses. This mistaken idea has been helped by the description given in Hopwood's book, *Living Pictures*, and on seeing what he had written, I told the author he was wrong. Unfortunately after Hopwood died, Mr. Bruce Foster, also of the Patent Office, repeated the error in a second edition. He has, however, written me the following letter:

"I have been away for a few days and have been looking through the various documents you have sent me, more particularly in respect of the bearing of the information thereon in the relevant matter in Hopwood's *Living Pictures*—for the second edition of which I must plead guilty.

"There can be no question of fact that Le Prince's specification of 423/1888 includes the proposition of a 'one-lens' camera and projector. The specification includes the following passage in addition to the claims cited on p. 7 of the pamphlet:

" 'When the receiver is provided with one lens only as it sometimes may be, it is so constructed that the sensitive film is intermittently operated at the rear of the said lens which is provided with a properly timed intermittently operated shutter, and correspondingly in the deliverer, when only one lens is provided, the band or ribbon of transparencies is automatically co-operated so as to bring the pictures intermittently and in the proper order of succession opposite the said lens.'

"It is a matter for regret that this aspect of Le Prince's specification was not brought out clearly in the second edition of Hopwood's book. The reason probably was that the specification described in greater detail the multiple-lens construction. This fact cannot, however, be relied on to exclude a 'one-lens' construction according to the specification.

"If, as it would appear from the information you have, the film referred to on p. 6 of the pamphlet shows Mrs. Whitley walking in the garden, and can be identified as taken with a 'one-lens' camera, then, as Mrs. Whitley died on the 24th October, 1888, these facts alone would appear to date the 'one-lens' camera as made before that date.

"I am sorry the storm of controversy should be so tied up with the detailed paragraphs in Hopwood's *Living Pictures*, and apart from my regret that the existing text does not give due weight to the 'one-lens' proposition in the specification of 423/1888—if the story has to be rewritten—it will have to be modified also in other particulars, in the light of new facts which were not put in my possession when the second edition was published.

"(Signed) E. BRUCE FOSTER."

Le Prince worked with collodion and gelatin for several years and, when living in New York, must have heard that Hyatt Bros., of Newark, were engaged on the problem. They made sheets of trans-

parent celluloid by veneering it from a large block. Afterward it was made by spraying on glass.

John Carbutt sold sensitized celluloid sheets late in 1888, and showed this material and photographs made on it at the Franklin Institute, Philadelphia, in November of that year.

Rev. Hannibal Goodwin, of Newark, N. J., was evidently in touch with Hyatt Bros., for in 1887 he knew enough about the possibilities of celluloid film to apply for an American patent in that year. Dr. Marey, of Paris, is said to have used sensitized film in the late eighties.

There is very little doubt that long sensitized celluloid strip became available in 1889, and Le Prince had some reels of it in that year. Frederic Mason was employed to cut each reel into two to suit Le Prince's machines, as declared before a Commissioner. (See appendix.)

The 1889 patent of W. Friese-Greene and Mortimer Evans makes mention of "sensitive photographic film;" however, there is no special merit in mentioning a material which anyone could buy. If celluloid film had been on the market when Le Prince applied for his first patent $2^1/_2$ years before, *i. e.*, in 1886, he would most certainly have mentioned it along with the other materials.

Le Prince had trouble with his film cockling and getting on fire with the heat of the lamp, and the water screen he made is thus described by Longley:

> "It was made of two plates of glass and thick India-rubber put between and clamped with brass plates across, also two syphon tanks so that the water was continually changing."

They fully recognized that in the use of sensitized celluloid film the last hurdle had been cleared. It was the production of satisfactory transparent, pliable, and robust films that finally brought motion pictures into commercial use in the middle nineties. In that work many inventors, engineers, and commercial men helped.

In the spring of 1890, Le Prince decided to return to his family in New York, and ordered special boxes to be made to carry his apparatus. These boxes recently came back to Leeds as containers of the original apparatus, which was shown at the unveiling of the memorial.

In preparation for showing her husband's apparatus and pictures, Mrs. Le Prince rented the Jumel Mansion in New York and had it redecorated. The home life of the family was ideal and she was a splendid helpmate.

"Proof of working" of his first French patent was granted in June,

1890, and there is no doubt but that he then had business in that country. In August he went to France with his friends, Mr. and Mrs. Richard Wilson, and left them at Bourges to visit his brother, an architect and surveyor of Dijon. He was last seen entering the train for Paris at Dijon on September 16, 1890, and then he disappeared, together with his luggage. Intensive searches were made by French and English detectives, but not a single clue was ever discovered.

Some time after his disappearance, Mr. Richard Wilson collected such things as he thought worthy of preservation. As a banker he did not know their technical and historical value, and thus films, *etc.*, were lost that would now be considered valuable. Charles Pickard, commercial photographer of Leeds, has the tripod of the camera and Frederic Mason picked up a few photographs.

It will be remembered that much the same thing happened in the case of Friese-Greene, practically all his apparatus being sold for "junk," only a few pieces of film being saved. In the case of Friese-Greene, no machines remain, but in the case of Le Prince there are two, fortunately, to testify to his ingenuity.

When it became certain that her husband was lost, Mrs. Le Prince consulted with Mr. Choate, sometime American Ambassador to Great Britain, but all he could tell her was that she would have to wait until the death could be legally "presumed," which took seven years. In 1898, the eldest son visited England and France and took back to New York the camera and other things, some of which are now deposited in the Science Museum at South Kensington.

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[1] SCOTT, E. KILBURN, "The Pioneer Work of Le Prince in Kinematography," *Phot. J.*, **63** (Aug., 1923), pp. 373–8.

[2] CRAWFORD, MERRITT: "Louis A. A. Le Prince," *Cinema*, **1** (Dec., 1930), pp. 28–31.

APPENDIX

DECLARATION OF FREDERIC MASON*

In 1887 I was near the end of my apprenticeship with my father's and brother's firm, Wm. Mason & Son, joiners and contractors, of 150 Woodhouse Lane, Leeds, and one day there came to the works a Mr. Louis Augustin Aimé Le Prince who previously had been with Whitley Partners of Hunslet, and also had a Technical School of Art in Park Square, Leeds.

* Builder, 11 Quarry Mount, Hyde Park, Leeds, England.

He said that he required some woodwork which must be very accurately made, and it was given to me to carry out. During the next $2^1/_2$ years I was engaged almost continuously for Mr. Le Prince. I made all the woodwork and the patterns for metal castings.

I discovered that he was constructing apparatus for the purpose of taking photographs in rapid succession and projecting them on a screen, so as to give the illusion of motion; in other words—moving pictures.

Mr. Le Prince equipped a workshop at 160 Woodhouse Lane, now occupied by the Auto Express Company, on which a bronze memorial tablet was unveiled by the Lord Mayor of Leeds on December 12, 1930.

At this unveiling the camera which Miss M. Le Prince brought from New York was shown, and this I at once identified as the one I assisted to make and which was completed about the summer of 1888. It was constructed to scale drawings made by Mr. Le Prince; he was a very clever draughtsman. The metal parts were cast at Whitley Partners and machined and fitted by Mr. J. W. Longley, who was the mechanic of Mr. Le Prince.

The camera has two lenses, one being for taking the photograph and the other for the view finder. The gate mechanism behind the lens is constructed to hold the film firmly in position during exposure, and then to momentarily release it while being drawn upward without it being scratched. The intermittent movement consists of a toothed cam which engages with a projection on the side of the top reel, the latter pulling the film through the gate and also winding it up.

The handle projecting from the side of the camera operates the mechanism through gear wheels. A brass shutter revolves in front of the lens which has in it an adjustable diaphragm. Turning the handle at the proper rate enabled pictures to be taken at the desired speed.

For his cameras Mr. Le Prince used sensitized paper film and gelatin stripping film. Miss Le Prince brought along with the other apparatus a reel of the paper film which was found in the camera.

In the early autumn of 1888 the camera was used for photographing a series of pictures, at about 12 per second, in the garden of Mr. Joseph Whitley, father-in-law to Mr. Le Prince. In them Mrs. Joseph Whitley is shown, and as she died on 24th October, 1888, this conclusively shows that the series was taken before that date.

Another series, taken about the same time, but at a higher speed, was from a window of Hick Brothers, Ironmongers, from whom he had purchased tools and materials. Their premises are at the southeast corner of Leeds Bridge, and the pictures showed very clearly the moving of traffic across the bridge.

Mr. Le Prince found the construction of the projecting machine much more difficult than the camera; it evolved through several stages, and when making changes existing parts were re-used as much as possible. One projector had three lenses, and was like a sketch of Mr. J. W. Longley's which he sent to Mr. Adolphe Le Prince in 1898, a photostat copy of which is in my possession (Fig. 7).

As indicated in his patent specification, Mr. Le Prince first dealt with the positive pictures by mounting them on bands, one material that he used being thin red fiber. Small holes were punched along the edges of the bands to engage with pins in the sprocket wheels.

In his earlier experiments Mr. Le Prince used oxy-hydrogen lime-light, but when finally he was able to get quick enough movement of pictures to employ only one lens, then he decided to have an arc lamp. This involved installing an electric generating plant, and he called in the assistance of his friend, Mr. Wilson Hartnell, electrical engineer, who lived close by in Blenheim Terrace.

He supplied a dynamo and arc lamp, and his men installed them and ran cables over the roofs of intervening buildings from our yard at 150 to the workshop at 160 Woodhouse Lane.

The dynamo was driven by belt from our semi-portable Robey engine and boiler, which I operated at night. I have reason to remember the first time because Mr. Le Prince sent round that he wanted a higher voltage, and I took the risk of placing extra weights on the safety valve in order to get more speed on the dynamo.

When the arc lamp was first switched on there were present, besides Mr. Le Prince, Messrs. J. W. Longley and Walter Gee, the last-named being an electrician for Mr. Hartnell. He is now chief engineer to the Barnsley Co-operative Society. They were the first people to see moving pictures projected with the arc lamp illumination, but afterward a few others had an opportunity, including Mr. Hartnell and my brother William; the latter said the pictures showed well except for some flickering.

It is important to note that details of the camera and projector with which Mr. Le Prince did his best work in Leeds departed considerably from those shown in his British patent No. 423 of 1888 and his United States patent serial 217,809 of 1886. It was his intention to take out further patents, and naturally he was therefore reluctant to show his machines.

Miss Le Prince brought back with the camera, *etc.*, two long reels which her father had built up of strips, each about 3 inches wide and a foot long, fastened together and having silver along the edges to keep the layers apart. These he used for developing films.

At a later date, long reels of somewhat similar material, sensitized and nearly transparent, became available. It would be in the early autumn of 1889 that Mr. Le Prince came to me in high spirits to say he had obtained some rolls of sensitized film called celluloid. As these were too wide I cut them in halves on a lathe, working with a red lamp at night. The incident is clear in my mind because I had to wait until it was dark, about 9 P.M.

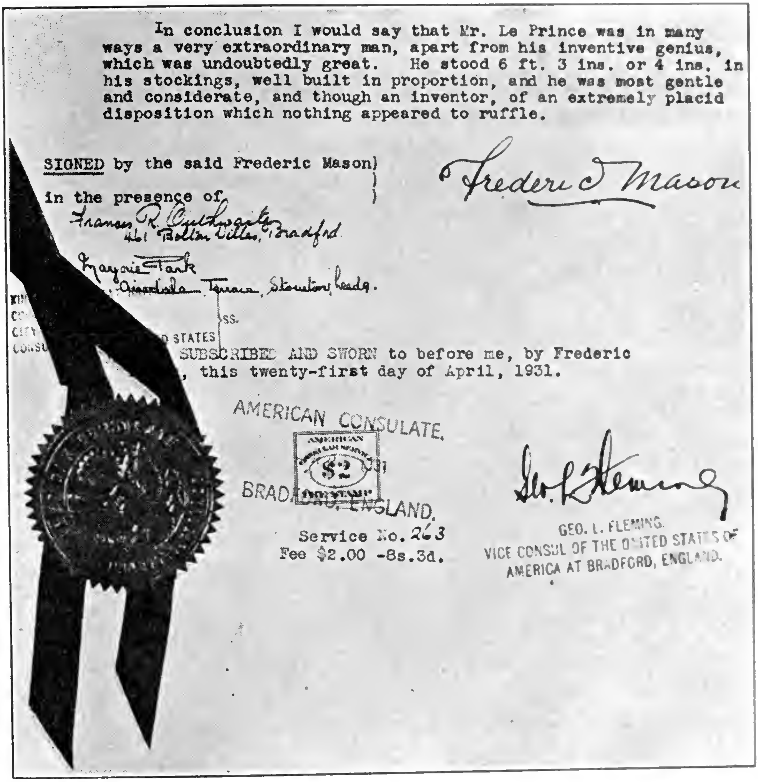
The coming of celluloid film solved the last difficulty, and in the spring of 1890 Mr. Le Prince decided to go to New York, where his wife and family were, to show moving pictures there. He ordered from Mr. Trinder, a maker of portmanteaux in Woodhouse Lane, special cases to hold the apparatus. The cases which Miss Le Prince brought back were the originals with the maker's name still on them.

Before sailing he went to France to see about patent business, also to bid adieu to his brother, an architect and engineer of Dijon, who saw him off at the station en route for Paris on 16th September, 1890. Unfortunately, from that moment he disappeared completely and, although exhaustive enquiries were made by detectives and members and friends of the family, no clue was ever found.

After waiting about a month, Mr. Longley and myself entered the workshop and found everything quite normal, the machines intact, and tools, drawings,

photographs, as well as a quantity of discarded material, lying about. Mr. Richard Wilson, a friend of the family and manager of Lloyds Bank, Leeds, took charge of all the effects and proceeded to dispose of such parts as could readily be sold.

A large tripod I made for the camera passed into the possession of Mr. Charles Pickard, photographer, of Leeds, who showed it at the unveiling ceremony. I picked up a few relics, and am sorry now that I did not secure some exposed



In conclusion I would say that Mr. Le Prince was in many ways a very extraordinary man, apart from his inventive genius, which was undoubtedly great. He stood 6 ft. 3 ins. or 4 ins. in his stockings, well built in proportion, and he was most gentle and considerate, and though an inventor, of an extremely placid disposition which nothing appeared to ruffle.

SIGNED by the said Frederic Mason)
in the presence of, Frederic Mason

Frances R. Cuthwaite
461 Bolton Villas, Bradford.

Marjorie Tank
Ginesdale Terrace, Stourton, Leeds.

SS.

STATES

SUBSCRIBED AND SWORN to before me, by Frederic
, this twenty-first day of April, 1931.

AMERICAN CONSULATE,
BRAD ENGLAND.

$2

Service No. 263
Fee $2.00 -8s.3d.

Geo. L. Fleming
GEO. L. FLEMING.
VICE CONSUL OF THE UNITED STATES OF AMERICA AT BRADFORD, ENGLAND.

FIG. 8. Signatures and witnesses to declaration by Frederic Mason.

films and the drawings, as unfortunately nothing was done to preserve them. That they might have historical importance was not appreciated.

Mr. Wilson retained the camera, parts of the projector, including a lens, the above-mentioned reels, and a machine with multiple lenses that Mr. Le Prince made in Paris in 1887 for the purpose of "proving his patent." They eventually went to Mrs. Le Prince in New York City, and were kept there until October, 1930, when they were brought back to Leeds by Miss Le Prince. They are now housed in the Science Museum, South Kensington, London.

In conclusion, I would say that Mr. Le Prince was in many ways a very extraordinary man, apart from his inventive genius, which was undoubtedly great. He stood 6 ft. 3 in. or 4 in. in his stockings, well built in proportion, and he was most gentle and considerate and, though an inventor, of an extremely placid disposition which nothing appeared to ruffle. (See Fig. 8.)

(Signed) FREDERIC MASON

Signed by the said Frederic Mason in the presence of

Frances R. Outhwaite
461 Bolton Villas, Bradford

Subscribed and sworn to before me, by Frederic Mason,
this twenty-first day of April, 1931.

(Signed) GEO. L. FLEMING

[Seal] GEO. L. FLEMING
Vice-Consul of the United States
of America at Bradford, England

PROGRESS IN THE MOTION PICTURE INDUSTRY*

Summary.—*This report of the Progress Committee covers the period October, 1930, to May, 1931. The important advances in the cinematographic art which are described are classified as follows:* (*1*) *Production,* (*2*) *Distribution,* (*3*) *Exhibition,* (*4*) *Applications of Motion Pictures,* (*5*) *Color Photography,* (*6*) *Amateur Cinematography,* (*7*) *Statistics,* (*8*) *Publications and New Books.*

Although no epoch-making discovery was made during the past six months, there has been an evident improvement noted in all branches of technical endeavor in connection with sound recording, processing of records, and sound reproduction. Ever since the showing of the first successful feature sound picture in October, 1927, the quality of sound reproduction has been gradually improving. The reproduction of sound reached a high level of perfection during the past winter, due to the introduction of methods for eliminating ground noise in both variable density and variable width recording. Equally significant were the marked improvements noted in the speed and color-sensitiveness of panchromatic emulsions.

To facilitate the recording of sound under difficult studio conditions as well as to secure high-quality pick-up at a greater distance from the source, a microphone having directional pick-up was devised. Microphone concentrators, announced in the previous report, have found extensive use. An increase was also noted in the use of truck shots, both from small portable "dollys" as well as from more elaborate towers or camera parallels.

Noteworthy changes in camera design were made which minimize noise and made unnecessary the use of "blimps" or sound-proof coverings except for close-up shots. Aluminum housings for incandescent lighting equipment were claimed to have improved the portability of such units and to have eliminated the noise which commonly attends the warming up of lighting equipment.

Further data were accumulated both by individuals and committees on the important problem of acoustics of sound stages and theater auditoriums. Most major producing organizations in the United States recorded sound on film exclusively, re-recording on

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* May, 1931, Report of the Progress Committee. Presented at the Spring, 1931, Meeting at Hollywood, Calif.

disks when necessary for release purposes. Recording of pictures in France, England, and Germany settled down to a routine practice. Equipment for recording was installed in Italy, Russia, Japan, India, Brazil, and other countries.

Laboratories were faced with the problem of improving their processing methods in order that all the benefits to be derived from the introduction of "noiseless recording" might be realized. The construction of several new laboratories was either completed or well under way. The latest modern types of developing machines and inspection equipment were installed. An increasing demand was felt for greater care in previewing release prints.

Several subcommittees of this and other societies initiated the examination of the important aspects of projection, such as design and maintenance of projection rooms, screen illumination, monitoring and control of sound, and improvements in projection design. Further refinement in projector arc carbons was noted.

Although significant progress was made in a method of realizing stereoscopic pictures, one authority considered that much research will be necessary before the process will have practical value. The applications of sound pictures continued to multiply as government bureaus, business organizations, and pedagogical institutions began to use this new medium of expression. Although additional improvements were made in connection with methods of televising pictures, it was pointed out that a fundamentally new principle must be discovered in order that such processes may enjoy universal application.

Few color pictures were made during the past six months and exhibitors came to believe that color must be regarded only as an adjunct to the technical refinement of the picture, as, in its present form, it has been shown to lack real box-office value. Faster emulsions with better color-sensitiveness, coupled with improvements in processing, strongly indicated that subtractive processes would measure up to this requirement. The need for a satisfactory, inexpensive, three-color process still prevails and the announcement that a process is being developed by a leading American producing organization is encouraging.

Other than the introduction of a few new models of cameras, projectors, and accessories, the most interesting development in amateur ciné equipment was the announcement of a paper film for sound recording and reproduction.

The fertility of inventive minds was indicated by the relatively large number of patents issued in almost all the fields of motion picture technology during the past six months.

Acknowledgment.—Useful material for this report has been supplied by N. D. Golden and H. Griffin. A short article describing the Selenophone process was prepared by P. von Schrott, a member of the Committee residing in Vienna, and has been recommended to the Papers Committee for publication. Data prepared by A. Garrels, U. S. Consul General at Tokyo, was considered especially interesting and has been edited as an appendix to the report. Several reports containing pertinent information were furnished by L. Cowan of the Academy of Motion Picture Arts and Sciences.

Illustrations were supplied by the following companies: Consolidated Film Industries, Hollywood; Nela Lamp Works, Cleveland; RCA Photophone, Inc., N. Y.; and Radio Pictures, Hollywood. A number of illustrations from current Indian productions were furnished by the following: Imperial Film Company, Bombay; Three Krishna Film Company, Bombay; and Prabhat Film Company, Kolhapur City, India.

Respectfully submitted,

M. ABRIBAT	H. B. FRANKLIN	M. W. PALMER
L. BUSCH	J. G. FRAYNE	G. F. RACKETT
W. CLARK	E. R. GEIB	M. RUOT
A. A. COOK	A. C. HARDY	P. VON SCHROTT
C. DREHER	R. C. HUBBARD	H. SINTZENICH
R. E. FARNHAM	F. S. IRBY	S. K. WOLF

GLENN E. MATTHEWS, *Chairman*

SUBJECT CLASSIFICATION

I. PRODUCTION

A. Films and Emulsions

1. New Materials
2. Manufacture
3. Miscellaneous

B. Studio and Location

1. General
2. Lenses and Shutters
3. Cameras and Accessories
4. Exposure and Exposure Meters
5. Studio Illumination
6. Actors and Direction Technic
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1. Equipment
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VI. AMATEUR CINEMATOGRAPHY

A. General Equipment and Uses

1. Cameras
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I. PRODUCTION

A. Films and Emulsions

Concurrent with the general decline of business, which began late in the fall of 1930 and prevailed throughout the spring of 1931, there was an abandonment of the wide-film program by the producing organizations.[1] Cost of installations in the face of a business depression and insufficient public interest in wide pictures were two probable causes of this decision. Larger screens were installed, however, in a number of theater circuits. Warrenton[2] suggested exposing the picture in a 3 by 6 rectangle in the area occupied by one frame on 35 mm. film, retaining the principle action in a 3 by 4 area in the center of the longer rectangle. Prints could be made of the wide picture, or the smaller area could be printed optically to fill the entire frame.

The Standards and Nomenclature Committee, however, reported at the October, 1930, meeting of the Society that the only satisfactory method of obtaining a large screen picture seemed to be by using a wider film. A plan is being studied which will permit the use of a 1.8 to 1 ratio for the picture size, a wider sound track, more suitable margins, and a film width intermediate between 70 mm. and 35 mm. Two symposiums on methods of securing a large screen picture have been held by the Society in New York, one in October and one in December, 1930. At the last meeting pictures made on 65 mm. film by Paramount were shown, the picture frame having a ratio of 1.78 to 1. Several meetings dealing with this subject were also held on the West Coast under the auspices of the Technicians' Branch of the Academy of Motion Picture Arts and Sciences.

One of the most important developments for many years was the introduction of panchromatic emulsions of increased speed and improved color-sensitiveness, particularly in the red and green regions of the spectrum. With these ultra-sensitive materials, exposures may be made under more difficult conditions of illumination than with former emulsions or a better definition and depth of focus may

be secured by stopping down the lens. Such emulsions offer great promise in color photography where the difficulties of obtaining sufficient exposure have long been recognized. Greater care must naturally be used in handling these faster stocks both in the camera and in the processing laboratories. The industry is proceeding cautiously in using them, in order that the cameramen and technicians may have an opportunity to understand their characteristics.

Huse and Chambers[3] have published sensitometric data on Eastman Super-Sensitive Panchromatic film, showing it to be about twice as fast to daylight and three times as fast to incandescent light as previous panchromatic emulsions. The properties of Du Pont Special Panchromatic negative film have been discussed by White.[4] It is stated that set illumination may be reduced 40 to 60 per cent with this product. Filter factors are correspondingly lowered.

Faster emulsions for sound recording work have also been introduced, to replace the relatively slow positive film in common use. The saving of lamp current in sound recording is a vital problem, especially on location, as any reduction in the number and required capacity of storage batteries adds to the mobility of sound recording equipment. A negative sound emulsion is desired that would reduce present lamp current requirements about 50 per cent.

The practice of duplication of all valuable negatives is increasing. According to present technic, master positives are made on a lavender base positive emulsion, and the duplicate negative on an especially fine-grain, yellow-dyed emulsion, particularly made for duplication.

Paper emulsions were used in the Selenophone process for sound reproduction prints on amateur ciné apparatus.

Several patents have been issued relative to improvements in film support and emulsion manufacture. Five of these deal with sound film emulsions having a tinted support.[5]

Plans for the establishment of a factory at Elstree, England, to manufacture cellulose acetate base were announced in December, 1930.[6] The increased use of industrial and educational films is creating greater demands on the manufacturers of this type of film support.

A much smaller production of feature pictures in color was evident during the past six months than in the previous year, but trade reports indicated that there was an increased use of color for short features. Two industrial pictures were made by the Multicolor

bi-pack process. Another bi-pack process called "Magnacolor" was announced.[7] (See description under section on "Color Photography.")

A direct color process claimed to be applicable to motion picture film was announced as being available for exploitation in Germany. Colloidal silver emulsions are used which are developed in a closed container with the vapors of formaldehyde, ammonia, and alcohol.[8]

Originals and copies on horizontally embossed film by the Keller-Dorian process were exhibited by Paramount at a meeting of the New York Section in December, 1930.[9]

Some measure of the resistance of exposed but undeveloped photographic films to the action of water, snow, and ice was shown when the last camp of Andree was discovered on White Island in August, 1930. The films had been lying there since 1898. Professor J. Hertzberg of the Royal Technical University, Stockholm, Sweden, developed them and found that 50 of the 192 exposures contained traces of the image; twenty made satisfactory pictures when processed, thirty-three years after being exposed in the camera.[10]

B. Studio and Location

Refinements in methods of sound recording represented the most significant advance in American studio practice during the winter of 1930–31. Production in most of the European studios had settled down to routine work. In some of the more remote places in the world, sound recording equipment was still rather crude or entirely lacking, as, for example, in South Africa, South America, China, and India. In the last-named country the first native produced sound feature was scheduled for release in March, 1931. Data on recent progress in Soviet Russia was somewhat meager; a paper by Monosson presented at Washington in May, 1930, and a later article by Moshonkin, constituting the most reliable sources of information.[11]

Lenses and Shutters.—Dubray[12] has discussed the color correction of objective lenses, reporting that achromatizing at the *C* and *G* lines of the spectrum gives better performance than the usual photographic correction. Lenses computed to this specification have been marketed. The depth of field of optical systems has been analyzed by Hardy,[13] who applied the results to the different methods of realizing large screen pictures. It was shown that the greatest depth of field results, for the same final screen magnification, when

the focal length of the camera and projector lenses are kept as short as possible.

A new anastigmat of $f/2.8$ aperture, made by Carl Zeiss, Germany, supersedes the older $f/2.7$ lens. It is claimed to give uniformly good definition at all apertures.[14]

Only a few patents were issued on lenses and shutters and of these the majority dealt with minor improvements in shutters.[15]

Cameras and Accessories.—The bulky, heavy "blimps" or sound-proof housings for cameras are gradually being displaced by insulation within the camera body itself. Many improvements have also been made in silencing the actual mechanism of the camera.

Nearly 80 per cent of the inherent noise of the usual Bell & Howell camera shuttle movement was claimed to have been eliminated by removal of part of the back register leaf so that four steel wires actually move the film on and off the pilot pins.[16] A novel camera construction from the Warner Brothers studios had its first public showing in October, 1930. According to Stull,[17] features of the new camera are an enclosed movement and a lens which moves only in a horizontal plane during focusing by making the entire turret movable.

The Fearless Camera Company recently perfected a new camera which is adapted for use either with 35 mm. or wider film up to 50 mm. No housing is required for all average camera work and the cameraman may use it for recording sound directly in the camera if so desired. Other features are (1) a new type magazine which is easily threaded, is very free-running, and is stated to eliminate trouble from film jamming, and (2) an adaptor holding two ordinary magazines as used in bi-pack color photography.[18] An improved Debrie camera fitted with a synchronous motor has been described briefly.[19]

During the last six months, there has been a marked increase in truck shots in which the camera is mounted on a "dolly," or perambulator, which is moved with or around the action during the progress of a scene. The director, in one sense, edits the picture on the stage during actual production. Great precautions are taken to avoid noise when the truck is moved. In some instances the microphone boom is mounted on the truck with the camera, but as a rule microphones are manipulated from a separate position. Sometimes two or three booms are necessary to cover the sound during a long scene.

In making *Cimarron*, *The Lady Refuses*, and several other pictures, a more elaborate truck was found useful (Fig. 1). Parts of an

FIG. 1. Special camera parallel and truck.
(Reproduced by courtesy Radio Pictures, Inc., Hollywood.)

automobile chassis were used in its construction. A central tower was built which could be raised to a height of 23 feet. Additional platforms were also available so that the truck accommodated

about six people, two cameras, a microphone reflector, and other accessories.

Numerous patents on improvements in camera design have been issued.[20] A few patents were granted on cameras for taking pictures having stereoscopic effects.[21] Non-intermittent movements in cameras were also protected by patents.[22] Patents were issued covering a variable film feed mechanism, a camera for taking pictures in a spiral arrangement on a transparent disk, and a process for motion picture time studies involving control and numbering of the frames of the film.[23]

Exposure and Exposure Meters.—Various methods, both practical and theoretical, for determining filter factors have been discussed by Chibissoff and Michailowa.[24] Dubray[25] has described an exposure meter which measures the adaptation level. The instrument was devised by Norton. A method of determining exposure, worked out by Loveland,[26] consists in developing, in a rapid working solution, a trial exposure on a strip of film which previously has had a sensitometric exposure on a separate area from the picture. Comparison of two or more densities of the picture and of the graded strip gives a measure of the exposure.

Studio Illumination.—One of the outstanding developments in studio lighting equipment during the past six months was the production of silicon-aluminum housings designed particularly to eliminate the objectionable noises commonly given off by the older sheet-iron housings when a lamp is warming up. An unequal expansion occurred in the older type lamp between the inner and outer sheet-iron housings over a cast-iron frame. Several manufacturers have produced this solid aluminum equipment of which some designs are made of four casings bolted together, and others, of a single large unit. Common sizes in use are an 18-inch unit for a 2000-watt lamp and a 24-inch unit for the 5000-watt lamp. When it is undesirable to increase the number of 1000-watt or 1500-watt units, large reflector types are used, fitted with 5000-watt, 115-volt lamps which distribute their radiation over an angle of 25 degrees.

Lamps employed for studio work have been strengthened greatly to make them more resistant to rough treatment. The use of heat-resisting glass has greatly reduced the tendency for discoloration and has improved the ability of the lamps to withstand high temperatures.

Arc lamps of German manufacture and accessories for the elimination of arc noises were described by Körting and Matthiesen.[27]

Actors and Direction Technic.—According to U. S. Department of Commerce trade reports, a British college for training actors has been inaugurated. The course lasts nine weeks and includes deportment, stage acting, elocution, and make-up.[28] Universal Pictures are stated to be planning a practical training school for actors which will include instruction in sound recording, costuming, set design and construction, make-up, and actual acting before the camera. Griffith[29] has been granted a patent on a method of introducing peculiar light and shadow effects by interposing a semi-transparent screen between the camera and the player.

Trick Work and Special Process Photography.—In the making of a well-known type of sound cartoon, the sound score is prepared first and the scenario is then written under the score. The number of sketches for each musical note is calculated. A staff of 20 artists prepare about 5000 pen and ink sketches for each release, working about one month to complete a picture requiring only 6 minutes for projection.[30]

Patent protection was granted on a method of preparing a cartoon film for subsequent synchronization with an existing sound record film, as well as on a process for making composite pictures in which two objects at different distances and in different directions are photographed on the same film.[31] Pomeroy[32] has disclosed a process for producing composite photographs embodying two component images.

Sound Recording.—According to Knox,[33] the problems of the sound engineer are: (1) extension of the frequency range of recording and reproducing equipment; (2) increasing the volume range so that fainter and louder sounds can be recorded and reproduced; and (3) reducing ground noise to a minimum. Lichte[34] has discussed in a general way the problems of sound recording associated with German equipment, laying particular stress on the underlying causes of distortion. Dreher[35] has reviewed recent progress in sound recording both by variable density and variable width processes.

A most significant improvement in the quality of sound reproduced from variable density records has resulted from the introduction of the biased-valve method of recording by Western Electric. By this method, ground noise has been reduced 10 db., according to

Silent.[36] An auxiliary circuit is associated with the light valve, and when the sound currents are small, the ribbons vibrate over a small amplitude. As the sound increases, the spacing between the ribbons is increased automatically by the auxiliary circuit. Thus, the sound print is darker for weak sounds and lighter for strong sounds. About forty features had been produced up to April, 1931, using this method of recording. Full benefit of the system can be derived only by proper development of the sound track and close coöperation is therefore necessary between the sound department and the processing laboratory. The introduction of improved methods of recording has raised the question of reducing noises in theaters emanating from fans, ventilators, and projectors, and consideration is being given this question.

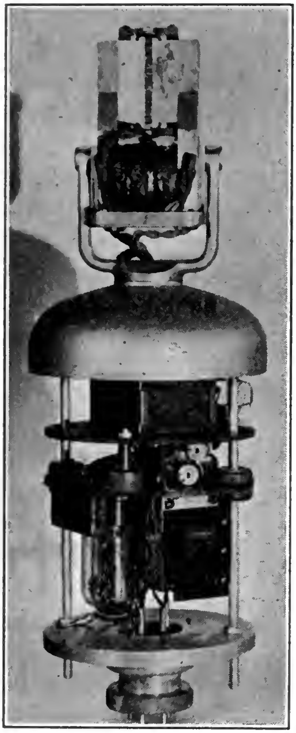

FIG. 2. Directional pick-up microphone.
(Reproduced by courtesy RCA Photophone, Inc., N. Y.)

Another method of reducing ground noise is described by Townsend, Clark, and McDowell for use in variable width recording.[37] A shutter in the path of the light beam is automatically moved to cut off as much light as possible, consistent with carrying the modulation. In principle, this scheme, like the Western Electric "Noiseless Recording" process, consists in rectifying a portion of the output of the recording amplifier, and using this current to keep the amount of light admitted to the film at a minimum.

According to reports from the West Coast studios, the practice of re-recording by electrical means is increasing and the present tendency is to incorporate sound effects into the original sound track after it has been recorded and developed. It is often possible by this method to shoot scenes without sound equipment and add the sound effects later in the dubbing process. Loss of quality in re-recording which may be partly attributed to defects in dubbing

machines has been greatly reduced by improvements in such apparatus.

A new type of microphone, for which directional pick-up characteristics are claimed, has been developed by RCA Photophone[38] (Fig. 2). The operation of the microphone depends on the induction of electric currents of audible frequency in an extremely thin and light corrugated aluminum ribbon, placed between the poles of an electromagnet, and caused to vibrate by the acoustic wave. Sounds normal to the face of the microphone are picked up whereas sounds at angles to the normal are received very feebly if at all. It is possible to secure high-quality pick-up at a greater distance (usually about double) from the source than with a condenser type microphone. When used on microphone booms, the amplifier associated with the microphone is removed to reduce the carrying weight.

Details of construction and advantages of the use of microphone concentrators were treated by Dreher[39] at the fall meeting of the Society in 1930. High-quality sound pick-up is made possible at distances of from 20 to 40 feet and concentrator microphones are finding extensive use for outdoor work, particularly in conjunction with trucking shots. Improvements in carbon microphones for use in sound recording have been discussed by Jones.[40] The introduction of an air-damped, stretched diaphragm and a push-pull arrangement of two carbon elements has increased the fidelity of reproduction.

A description has been published by Kellogg[41] of a new recorder for variable width recording which employs a magnetic drive to secure uniform speed. In a power amplifier system described by Thompson[42] two tubes with matched grid-current *vs.* grid-voltage characteristics are used in a push-pull circuit. Vogt,[43] one of the inventors of the German Tri-Ergon method of recording sound, has dealt with the influence of the slit width on the accuracy of representation of photographically recorded sound frequencies. Both von Hartel[44] and Livadary[45] have treated other aspects of this important subject.

The matter of acoustically treating sound stages and theaters continued to receive active consideration. Linck[46] has reported the results of oscillographic studies of sound in several types of rooms. Interference effects caused by differences in time and position were examined by Kuntze[47] who used a circuit with two microphones to simulate binaural reception. On the West Coast, one of the equipment manufacturers has built an acoustic laboratory fitted to make

absorption and transmission measurements over a wider frequency band than has ever before been attempted (Fig. 3).

The use of a third electrode in flashing lamps for recording by causing continuous ionization of the gas present, eliminates the hysteretic effect due to the difference between the ignition voltage and the extinguishing voltage.[48] Milkutat[49] has dealt with the subject of volume control, especially with regard to the effect of echo in the recording studio.

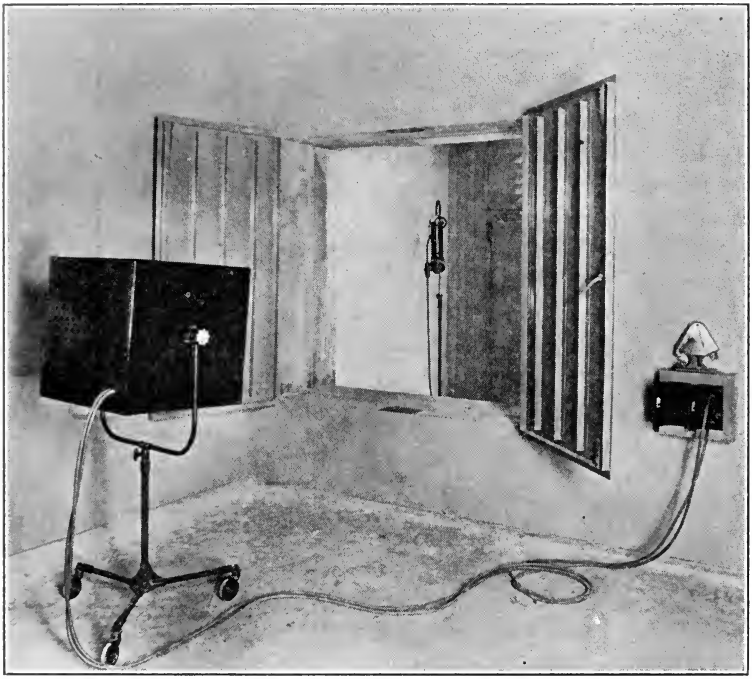

FIG. 3. Reverberation chamber in acoustic laboratory. Panel to be tested is placed in opening between the two rooms.
(Reproduced by courtesy Electrical Research Products, Inc., Hollywood.)

RCA Photophone has designed a compact sound recording truck fitted with a monitoring and a recording compartment.

Robillard and Lyford[50] have published details concerning recent developments in RCA portable recording equipment, such as the optical system, galvanometer, and amplifier. Studio equipment supplied by the same firm was described by Dutton and Read,[51]

the features emphasized being constant impedance mixing, a filter for eliminating low rumbles, and a recording amplifier with two output channels.

The entire Tanar sound truck is insulated to serve as a monitor room, sufficient amplification being supplied for four microphones.[52]

As was foreseen, film recording is tending to replace disk recording, because of the greater ease of editing sound records on film and the introduction of methods of reducing ground noise, whereas disk recording affords little opportunity for further reduction in surface noise. All the major producing companies in the United States now appear to be making their original recordings on film. Re-recording is done when disks are required for release.

A single string oscillograph is used in the Selenophone (German) method of recording, and the apparatus is so designed that eight ordinary sound tracks can be recorded side by side across the film width. A selenium cell designed by Thirring, a condenser type, is used as the light-sensitive element. The company has developed a method of recording on paper for use with amateur equipment.[53] (See Section VI.)

Various processes and equipment used in French studios for recording sound in conjunction with pictures have been described by Bonneau.[54] According to a report from India, sound pictures are becoming increasingly popular especially since recording equipment has become available. Three companies have recording equipment, and the first all-Indian feature picture scheduled for release in March was recorded in Hindustani, a step which may help to a considerable extent in unifying the 300 odd dialects at present used.

A great many patents have been issued particularly in the United States and Great Britain dealing with improvements in processing of sound recording in conjunction with motion pictures.[55]

Set Construction.—A material consisting of pressed fir and balsam wood has been developed to prevent loud reverberations on street pavements used in sound picture sets.[56] Sets for silent pictures were usually built of three-ply wood veneer, covered with wall-paper, or painted to give the effect desired. These materials cause reverberation which interferes with the fidelity of the sound pick-up, particularly on long shots. Thin unbleached muslin cloth, properly stretched, eliminates reverberation almost entirely and permits much greater flexibility in sound recording. It is often possible,

with such sets, to take medium and close-up camera shots simultaneously, using only one sound pick-up.

Costly retakes are thus avoided and production expenses correspondingly reduced. A set made entirely of cloth is a rarity but it is not uncommon for cloth to constitute 75 per cent of the entire construction. Opaque material is used to back the cloth to prevent light from showing through and door frames must be carefully constructed to avoid transmitting vibrations to the cloth.

C. *Laboratory Practice*

Equipment.—Since the advent of the sound picture, the technic of laboratory processing has improved considerably. The significance of sensitometry in relation to sound and picture quality is being realized more and more each year. Recent processes for reducing ground noise demand great care in developing the film. In the field of sensitometry there has been a tendency to concentrate on time scale devices rather than on intensity scale instruments. There is a need, however, for some agreement on a particular type of instrument so that comparisons between controls at various studios can easily be made. A diffuse reading densitometer designed by the Bausch & Lomb Optical Company has found application in three West Coast laboratories. Densities as high as 4.0 can be read with a high degree of accuracy.

Two large processing laboratories were opened during the past six months in Hollywood, Calif., and two others are known to be under construction.

Lob[57] has discussed the optical systems of a number of different types of photometers for making subjective density measurements. Four adaptations of the comparison microscope were considered by Conklin[58] at the Fall, 1930, Meeting of the Society. The action of photographic solutions on various construction materials with relation to their suitability for processing apparatus has been discussed by Crabtree, Matthews, and Ross.[59]

Only two patents were noted dealing with processing equipment.[60]

Photographic Chemicals and Solutions.—One of the outstanding problems with regard to all film developing machines is that of maintaining a constant rate of activity of the developer. A paper by Crabtree and Ives deals with a replenishing solution for a motion picture positive film developer. Specific directions are given for replenishing when developing by the rack and tank system, and

suggestions are made regarding the composition of the developer for machine development.[61] .

Valenkov[62] has discussed the significance of the "Eberhard effect"* in photographic photometry and concludes that the effect has little significance in spectrophotometry, is independent of the form of the picture, and occurs chiefly in areas smaller than 3 mm. in diameter. Rzymkowski[63] has continued his work on the chemistry of development and has reported on the role of sulfite in developers. Fogging action of hydroquinone developers with low sulfite content is believed due to the formation of a mono-thiosulfonic acid derivative of hydroquinone. Crabtree and Matthews[64] have discussed the effect on processing of motion picture film of various impurities, dissolved salts, extracts, and gases sometimes found in the water supply.

Processing Technic.—Problems facing laboratories are: (1) a means of quickly measuring the developing activity of a bath or the gamma to which the film is being developed; (2) a method of maintaining the bromide concentration constant throughout the life of the solution and recovering this salt from the bath; and (3) a non-staining developer for the development of variable density sound film.

General papers on sensitometric control of sound film processing have been published by Eggert and by Schmidt.[65] By impressing a sensitometric exposure on the beginning and end of a 1000-foot roll of variable width sound record film, according to Cooper,[65a] the cameraman can tell the degree of development independent of the exposure by examining the developed strip. The sensitometric exposure is made by using a weak alternating current for operating the oscillograph recorder, and allowing the recorder to come to a stop after turning off the current. By measuring the developed densities at marked intervals and the distance between the wave peaks, the gamma may be calculated.

An investigation has been started by a subcommittee of the Academy of Motion Picture Arts and Sciences on methods and standards to be followed in processing film. Formal recognition will be given to desirable standards on which there is general agreement.[66]

Light valve recording on the underexposure or "toe" portion of the characteristic curve is stated by Lewin[67] to be in use by Para-

* An increase in density of a small area inside a larger area which has received less exposure. Most apparent with short development.

mount for scoring and playbacks. It is claimed to be less sensitive to development errors. A system of counter-current flow in machine fixing baths is advocated by Landau.[68]

A patent has been issued for the use of a sound film having a latent image of a sensitometric strip printed at intervals throughout its length.[69]

Printing Machines and Methods.—The applications of dubbing, as described by Lewin[70] are (1) re-recording of completed features; (2) re-recording of dialog to mix sound effects; and (3) synchronizing of foreign voices to a picture, more correctly known as "doubling." Tuttle[71] has designed a compounded Geneva pull-down for motion picture printers which is essentially a Lumière cam mechanism running at high speed, provision being made for "idle strokes." A description of a semi-automatic sensitometer has been published by Crabtree, Ives, and Tuttle[72] in which the exposure intensity is equal to that in the motion picture printer. Stress is laid on the dependence of photographic quality on the intensity of the exposing light in a sensitometer.

Goldschmidt[73] has described a photometer for calibrating printing lamps which employs a photo-cell and a precision torsion galvanometer, reading directly in lux. A 4-volt battery supplies the necessary potential, low voltages being desirable in instruments used for this purpose. For printing "stills" in a German laboratory, a semi-automatic device is used. Two graduated filters may be moved simultaneously, one over the printing light and the other over a comparison lamp of fixed intensity. One-half of a matched field is illuminated by light which has passed through an average or important part of the negative and then through one of the filters, while the other half receives light from the comparison lamp through a second filter. A photometer which compares the extreme densities on the negative indicates the contrast grade of paper required.[74]

Improvements in printing equipment disclosed in patents include methods of printing sound film records.[75]

Tinting and Toning.—Crabtree and Marsh[76] have worked out a method of double toning of motion picture film which consists in toning the image blue in the usual iron toning bath, fixing in hypo, washing, re-toning, and lastly, immersing in a basic dye solution. Only one patent has been noted on a method of coloring motion picture film.[77]

Editing, Splicing, and Titling.—A growing demand exists for the

inspection of every release print regarding its sound and picture quality. One type of film inspection equipment consists of a standard Western Electric reproducer installed on a projector. The lower magazine is cut away to allow the film to be pulled back for hand inspection. Sound is picked up by a caesium cell and fed into an amplifier having an output ample for headset monitoring; with additional amplification, standard theater horns may be used. A sound head made by Vinten is being used in England for examining the quality of release prints.[78] In the Universal Laboratory, Hollywood, a final description of each release print is prepared by a stenographer who types the titles and identity of the successive scenes as the picture is projected on a small glass screen before her desk.[79]

A limited number of patents has been issued covering improvements in editing and splicing.[80] The introduction of sound pictures has greatly reduced the need for titles, as is apparent in the scarcity of patents on this subject.[81]

Cleaning, Reclaiming, and Storage.—Changes in the design of a well-known buffing machine for cleaning film have been described by Dworsky.[82] Patents issued include methods of waxing, humidification, surface protection, and elimination of scratches and abrasions on motion picture film.[83]

II. DISTRIBUTION

According to the Annual Report of the Academy of Motion Picture Arts and Sciences prints released during 1931 by practically all of the Hollywood studios will be prepared according to uniform specifications designed to facilitate threading, precision change-over, and exact synchronization.[84]

An interesting commentary on distribution problems appears in a report prepared by D. G. Clark, Assistant Trade Commissioner of the U. S. Bureau of Foreign and Domestic Commerce, residing in Johannesburg, South Africa. Because of the great distances between centers of population and the limited size of the usual theater audience, at least one-third of the distribution "life" of an average feature is consumed by transportation.[85]

III. EXHIBITION

The first of a series of small theaters was opened in March in New York City. For a small admission charge, the patron may witness the picture as projected on a daylight screen by rear pro-

jection.[86] A theater catering exclusively to children and seating over 1400 was opened in November, 1930, in Jersey City, N. J. Three performances are given daily; at 9.30 A.M., 2.00 P.M., and 4.00 P.M. There are no evening or Sunday performances.[87]

Pictures with several song inserts appeared to have lost their appeal to theater patrons during the past half year. American audiences have been trained to expect reality and the novelty of hearing a singing chorus with orchestral accompaniment in a desert scene soon wears off. In several of the sound pictures released during the early part of 1931 an evident effort was observed to reduce the amount of dialog, song, and dance, and to increase the sound effects in order to enhance the action.

A. General Projection Equipment and Practice

Practically an instantaneous change of lenses was stated to be possible with a new front plate assembly for the Powers projector. Other modifications are a lens centering device, a micrometer focusing pinion, a framing lamp, and an aperture change assembly.[88] According to an announcement in the German publication, *Die Kinotechnik*, the shutter on the Bauer M-7 projector is now arranged in front of the condenser lens in accordance with recent projector construction practice.[89] Descriptions of the Hahn II, Ernemann II, and Ernemann III projectors, all of German manufacture, have been published. The last-named projector has a lens mount capable of carrying lenses of 80 and 100 mm. diameter, thus permitting an aperture of $f/1.9$ to be used on lenses of almost any focal length.[90]

Features in the design of the Oemichen projector for Ozaphane film are: multiple tooth intermittment pulldown claws, low tension, separately adjustable gate shoe pressure springs, and friction rollers to assist feed and hold-back sprockets. These features are claimed to permit as many as 40,000 successive projections of a strip of film before it is worn out.[91]

Patent protection was granted on a considerable number of ideas relative to projector equipment and operation during the past six months.[92]

Sound Picture Projection.—The use of a separate projector for reproducing sound was initiated in a London theater, the Pavilion, in November, 1930. It is stated that this is the first time such a scheme has been utilized in a British theater.[93] For preview service, in Hollywood, one company has provided two portable dummy sound

projectors. These are installed in the theater and coupled to the regular projector before the preview. This permits the studio to have a preview of a production using the assembled intercut prints of both picture and sound track and eliminates the necessity of making a sound print which usually requires cutting after the preview.

A rotating disk instead of the usual friction gate is used to control film movement in a new type of sound projector.[94] A sound-film projector, suitable for theaters seating not more than 1000 persons, has been marketed. It is designed to operate on 110 volts, 50 to 60 cycles.[95] This equipment is one of several less expensive high-quality projectors for either film or disk records now available on the American market.

Sound reproducing equipment is being manufactured by a British firm which uses a magnetic coupling between the projector and the turntable. A single photoelectric cell is placed centrally between two projectors.[96] In another British sound apparatus, the photoelectric cell and amplifier unit are mounted on a chassis which may be inserted in the projector or removed quickly in case of failure of the unit.[97]

Difficulties encountered in equipping automobile sound-film projection units are discussed by Bull.[98] The lay-out and installation of a typical truck for outdoor projection is described. Natebus[99] has published a description of the Friess sound-film projector. The starting of the projector and fading are accomplished automatically by means of the film strip itself. The film is inserted in the projector for a change-over without regard to synchronization. Metallic contacts on the film then successively actuate relays which lower the needle into the proper groove, close the fader circuit, and extinguish the light in the first projector. Provision for automatic volume control is made and one type of equipment uses two disks, one above another.

In the Projectophone devised by Mihaly[100] the sound track image is projected by a suitable optical system onto the photo-cell located at some distance from the projector. If the detector is located at one side of the main projection screen, the advantage claimed is that it obviates the need of wiring between the projection booth and the screen and there is no risk of extraneous noise being introduced from generators. A caesium photo-cell is used.

The importance of periodically checking up the performance of

the sound equipment has been stressed repeatedly by writers in the trade publications. The paper by Wolferz is of interest, therefore, as it deals with a portable test set for measuring voltages testing circuits, amplifier and rectifier tubes, *etc.*, on any sound projector installation.[101]

Many theater stages have insufficient space backstage for a horn installation for sound picture projection. For such theaters, as well as for any theater where only a limited space is available for the loud-speaker installation, a shallow horn has been introduced by the Western Electric Company (Fig. 4). The horn is provided with twin air columns which meet in a common mouthpiece. The equipment is 26 inches deep, 107 inches wide, and 62 inches high.[102]

A super-electrodynamic speaker was described at the Fall, 1930, Meeting of the Society by Serge,[103] who emphasized the importance of the acoustical coupling between the loud speaker and the auditorium. A valve controlling the flow of compressed air into the small end of an exponential horn was introduced in a new type of reproducer as a useful asset to loud-speaker performance.[104]

Problems arising during synchronization of sound and picture records, especially records in different languages, have been discussed by Thun who dealt with the new Organon method worked out by the German Polyphone concern for overcoming unnatural synchronization.[105]

A rather detailed analysis of ground noise in relation to sound reproduction has been prepared by Tasker[106] who warns against vibrations in the recording equipment. Stryker[107] has shown experimental measurements of scanning losses under various test conditions to be in excellent agreement with those which would be anticipated from a theoretical study. The conclusion is drawn that with proper design and adjustment, optical systems need not be responsible for an appreciable loss of efficiency at the higher frequencies normally used in reproduction.

Changes in sound reproduction caused by varying slit width have been considered by von Hartel.[108] Besides presenting formulas showing the relation between the sound intensity and the width of the slit, the paper gives data showing that halation causes overtones which consist especially of octaves. A mathematical analysis has been made by Frieser and Pister of the effect on sound reproduction of a finite slit width, inclination of the slit to the direction of motion of the sound track, and non-uniformity of illumination of the slit.[109]

Livadry[110] has treated the relative efficiency of different optical slits and their frequency characteristics in sound recording and reproducing.

Frediani[111] avoids the use of photo-cells in reproducing sound

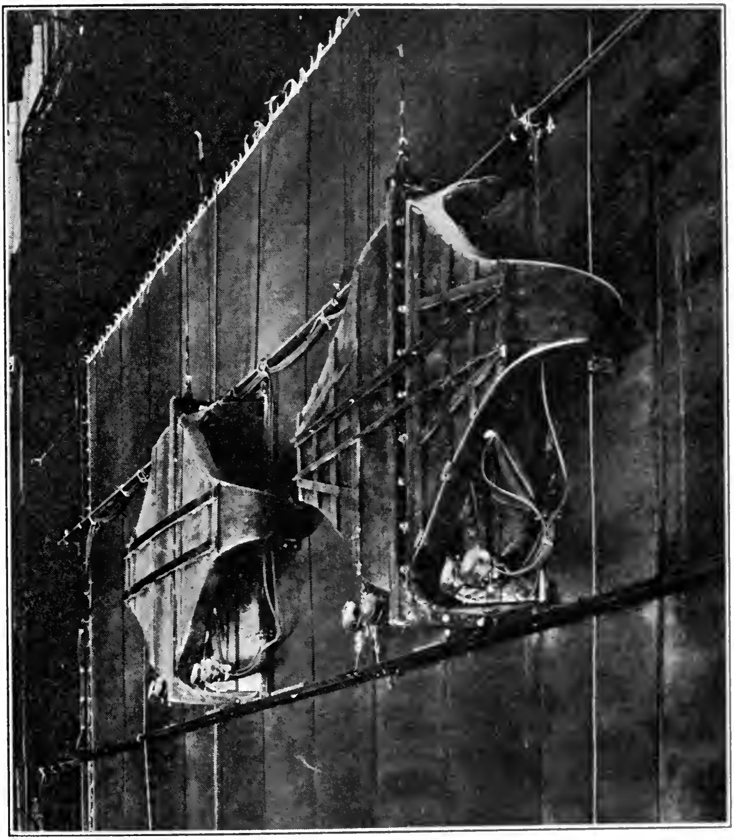

FIG. 4. Shallow type twin air column horn.
(Reproduced by courtesy Bell Telephone Laboratories, N. Y.)

from variable density records by passing them between electric contacts connected with the grid circuit of a thermionic amplifier. For such reproduction, paper prints may be used.

Hatschek[112] has published equations for the design of pick-up arms for disk reproduction.

A general paper giving details of photo-cell design has been published by Schroter.[113] A photo-cell made with cuprous oxide, according to another article, possesses high efficiency.[114] Roth[115] has dealt with recent developments in the Selenophone process which uses a selenium cell in connection with sound reproduction.

Graham[116] estimates that 10 per cent of the population who cannot hear sound pictures satisfactorily will be able to benefit from the use of a theater hearing aid device which he described in a paper. Articulation *vs.* loudness curves are used to determine the amount of aid possible for any particular degree of deafness.

Numerous patents were issued which disclosed improvements in sound reproduction equipment.[117]

Projector Lenses, Shutters, and Light Sources.—The recent use of screen pictures of large size has led to the development of lens turrets on projectors with objectives of the desired focal length ready to be moved into position to suit the requirements of the program.[118] Lenses of anastigmatic quality have been applied as objectives for theater projection work, as reported by Rayton.[119] Their aperture ratio of *f*/2.3 requires a special condenser system of large diameter if maximum screen illumination is to be secured. Schering has published a report on the efficiency of projection optical systems in ten German theaters, based on measurement of screen illumination.[120]

In a British process for securing a wide picture on the screen from 35 mm. film, a pair of achromatic cylindrical lenses is used, one concave and one convex, the ratio of foci being in relation to the degree of expansion of the image desired. A pair of spherical lenses is placed in front of the achromats to correct for aberrations. A similar lens installation is used in the camera except that the optics are arranged to compress the images.[121]

To utilize all the beam issuing from the film aperture of a projector using a mirror arc, Hauser and Mohr[122] conclude that the relative aperture of the objective lens must be greater than that of the mirror, defined by the ratio of the diameter of the mirror to the distance of its center from the film.

A limited number of patents was issued dealing with projector lenses and shutters.[123]

It is generally considered that little trouble from eye-strain is experienced by normal persons viewing a motion picture in a theater where the projection is satisfactory. This is particularly true in

the United States, but projection standards abroad are apparently not as satisfactory as they might be, as shown by the results of a questionnaire circulated among Italian school children, teachers, and eye experts. Thirty-three per cent of the children experienced eye-strain persistently or occasionally. For normal sight under good projection conditions, there should be no fatigue with shows of moderate length.[124] A British report suggests that a screen illumination of 7 foot-candles would be a feasible and suitable value. It is also proposed that the angle of elevation of the eye to the top of the picture should be limited to 35 degrees.[125]

Causes of variations in the light and steadiness of high-intensity carbons were discussed by Joy and Downes.[126] The demand for higher powered light sources in the theaters, using low-intensity reflecting arc lamps, has been met by the production of a higher current trim. This consists of a 13 mm. by 8 in. cored positive carbon and an 8 mm. by 8 in. cored negative. It is designed for 32 to 42 amperes at the arc. Previously, 32 amperes at the arc was the highest attainable. The introduction of a pre-cratered high-intensity projector carbon was also noted. These carbons are supplied as 9 mm. by 20 in. and are said to burn more quickly and smoothly.

Dash[127] has discussed the most suitable way of connecting generators for the operation of projection arcs. Naumann[128] has summarized methods for computing data on illumination in projection work.

Three French patents were the only ones noted which dealt with projection light sources.[129]

Fire Prevention.—Although no articles of significance were published during the past half year on the subject of fire prevention, the number of patents issued give evidence of the attention being given the subject by inventors.[130]

B. Special Projection Equipment

Effect Projection and Stage Shows.—During the presentation of the stage play *Miracle at Verdun*, at the Martin Beck Theater, New York, in March, 1931, sound motion pictures were combined effectively with the stage action. Three separate synchronized projectors were used to project pictures on three screens arranged back stage in the form of a huge cross. Six horns were used behind the screens and others above the proscenium arch and at points in the

auditorium.[131] A patent covering apparatus for projecting a plurality of sets of motion pictures was issued.[132]

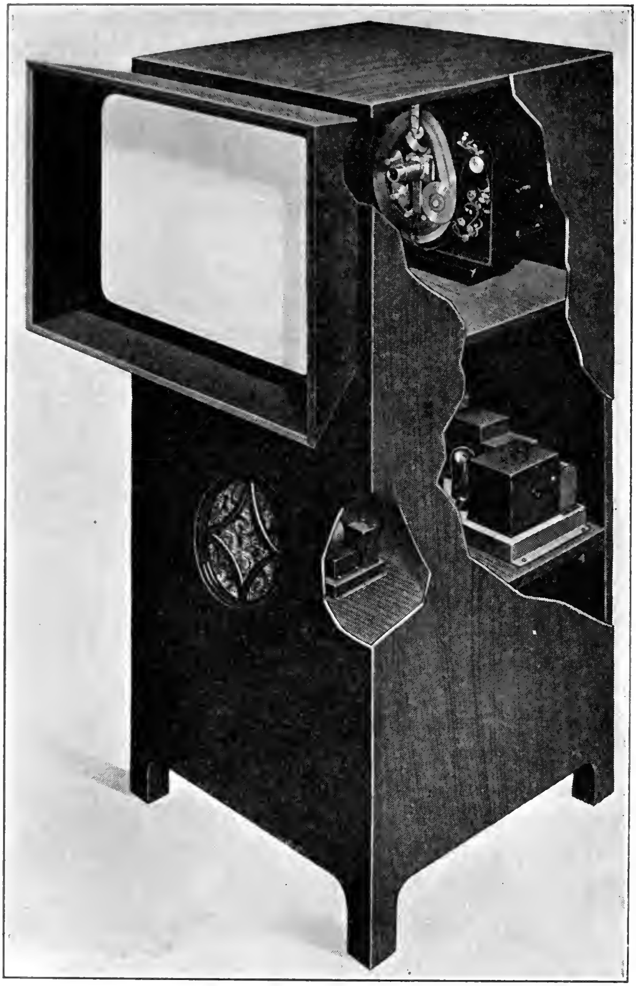

FIG. 5. Continuous portable sound-film projector.
(Reproduced by courtesy *Electronics* and Auto-Cinema Corp., N. Y.)

Portable Projectors.—Two new types of portable continuous projectors have been marketed, one for 35 mm. film and the other for 16 mm. film. Approximately 400 feet of sound film can be ac-

commodated on the 35 mm. projector (Fig. 5). Rear projection is used and the apparatus is entirely automatic. Only a few patents were noted which dealt with portable projectors and projection.[133]

Stereoscopic Projection.—According to Taylor stereoscopic vision requires that two eyes, related physiologically and psychologically, each view separately, distinctly different pictures. Several available methods for independent left and right eye vision are discussed in this article.[134]

Considerable research has been conducted by Ives to devise cameras and projectors for the production of pictures showing relief. The results of some of this work have been published in recent issues of the *Journal of the Optical Society of America.* The method consists, essentially, of making a series of pictures from juxtaposed points around an object and projecting the prints from these onto a special screen. The requisite properties of the screen are (1) the light beams must be reflected directly back toward the projectors with no lateral spread, and (2) a vertical spread or diffusion should be introduced. Two types of screens having these properties have been developed, one made of vertical solid celluloid rods and the other of strips of mirror.[135] More recently a stationary camera requiring only a single exposure has been devised but Ives indicates that much additional research is needed to perfect the process.[136]

A limited number of patents, chiefly French, have been issued relative to stereoscopic projection.[137]

Non-intermittent Projection.—Several interesting patents[138] have been issued on this subject recently but no articles of importance have been published.

C. Theater Design and Installation

Screens.—As noted earlier in this report, wide screens have been installed in many theater circuits as an aftermath, perhaps, of the wide-film movement. A larger picture has certain advantages which exhibitors desire and it is a simple expedient to mask the screen down for smaller picture projection if the larger screen is not desired. In connection with one group of theater operations, the following table represents the screen sizes used for various projection distances, all the dimensions being in feet:

Projection Distance	40	60	80	110	120
Height	8.5	11.5	14.5	17	19
Length	11.0	15.5	19.5	22	25.5

A diffused border is favored in the masking of close-ups. Kreuzer[139] has analyzed data for measuring light reflection and sound transmission characteristics of screens. A fire-resistant material for construction of motion picture screens has been announced which, it is claimed, will ignite with difficulty and will not propagate flame beyond the area exposed to the flame.[140]

A method of testing motion picture screens according to Little involves brightness measurements in two planes mutually perpendicular and perpendicular to the screen on which the incident beam is inclined at some angle above the screen axis. Tests of screen color in relation to the color of the light source are recommended.[141]

Three new types of screens have been described in the literature as being commercially available. A non-inflammable screen of rubber composition perforated with small holes was demonstrated in November, in London.[142] Another type of screen incorporates a cooling system for the theater. Behind the metal screen surface is located a refrigerating plant which causes the screen to become entirely coated with white frost.[143] In the third type, a non-glare and pseudo-relief principle is introduced. A pigment is used to cover the surface with a regular pattern which is claimed to absorb the harmful rays and reflect the remainder. The same amount of light is claimed to be reflected regardless of the viewing angle commonly prevailing in the average theater.[144]

Comparatively few patents were issued disclosing improvements in screens.[145]

Theater and Stage Illumination.—Shook[146] has described an instrument for the projection of "mobile color," which utilizes a single light source and three rotating disks on which are placed various optical devices and light filters. An instrument called the "Mutochrome" has been designed by Smith for projection of scenic backgrounds or color schemes for the design of decorative materials. It consists of a number of similar optical systems together with prisms for obtaining light from a common source.[147]

Theater Acoustics and Construction.—Since the advent of the sound motion picture, more and more attention has been given to the question of the size and shape of auditoriums. Physical requirements, such as plot, building restrictions, *etc.*, influence the choice. Any set formula is usually of little value but from experience to date it would appear that the most satisfactory results from the standpoint of sound reproduction are obtained in theaters having

a maximum seating capacity of not over 2000 seats. In theaters of much larger seating capacity, the sound quality suffers considerably when the auditorium is only partially filled, whereas in the smaller theaters this condition is not as serious.

A chain of midget motion picture houses is being planned for operation throughout the United States. The seating capacity will average about 200 and the shows will vary in duration from 15 minutes to 1 hour, as it is considered that some theater-goers desire only a short period of entertainment in their spare time.[148]

In connection with the statement that about 55 per cent of the 22,731 theaters in the United States are now wired for sound, it is of interest to learn that the Opera of Malta, which has remained practically unchanged since it was built 200 years ago, has recently been wired for the showing of sound pictures.[149] In an open air theater in Shanghai, China, the projector is enclosed in a cement booth and the sound screen has been placed before the back of the stage erected for dramatic performances. The theater seats 3000 persons and dialog can be heard clearly 400 feet back from the screen.[150]

Schlenker[151] has published a description of a portable laboratory for diagnosing theater acoustics. Results of a number of tests are included. A new type of electrical reverberation meter especially adapted to field work was described by Hopper[152] at a meeting of the Acoustical Society of America in December, 1930, at which time papers were also presented on several allied subjects. Hopper's apparatus consists essentially of a condenser microphone amplifier having a variable gain control, detector, relay, and cycle counter. An acoustimeter has been described which was designed especially for measuring reverberation times for auditoriums as well as noise levels existing in sound stages.[153]

According to a U. S. Government Bureau report, acoustic problems in Brazilian theaters are very difficult to solve. Walls are made of concrete or stucco and seats of plain wood. It is extremely difficult to use drapes as the insects attack most materials used. Electric current is quite unsatisfactory in many cities for sound installations. There is also a scarcity of skilled projectionists.[154]

IV. APPLICATIONS OF MOTION PICTURES

A. Education, Business, and Legal Records

Production of sound pictures has been initiated by the U. S. Department of Agriculture in its own studio in Washington. One

of the first pictures scheduled is the Indian sign language film which is being made for the U. S. Department of the Interior.[155] Officers of the U. S. Army are to be trained in the technic of sound motion picture production according to the announcement of the *Bulletin of the Academy of Motion Picture Arts and Sciences*.[156]

According to Baer[157] concrete experiences are a necessary prerequisite to the use of language, and visual aids, properly used, equip a group with a common body of life experiences. The various phases of the application of motion pictures as visual aids are stressed. Over three million dollars were spent for visual instruction in the 14 largest cities of the United States from 1923 to 1930.[158] *In the Days of Chivalry*, a school film edited from the feature picture, *Robin Hood*, was shown successfully in 20 public schools. It represented the first attempt to prepare an entire school film from a feature picture.[159]

Sound pictures are receiving attention in England. A regular series of educational newsreels is being prepared for British school and college distribution, using portable sound equipment if necessary.[160] Four one-reel sound pictures were shown on February 2nd in a West London school and questionnaires were distributed for teachers who will report on the relative merits of sound *vs.* silent pictures.[161] In December, 800 educational associations were called into conference at Burlington House to consider the value of motion pictures as a medium of education.[162]

In Finland, two associations doing educational work are using amateur standard film.[163]

Mogenson[164] recommends the use of motion picture films for the instruction of time study workers.

B. Medical Films, Radiography, and Ciné Photomicrography

At the Fall, 1930, Meeting of the Society, Morrison[165] described a laryngoscope for making full-screen pictures of the vocal cords at the rate of 16 frames per second. According to Schmidt, the Hamburg Film Archive, which specializes in medicosurgical subjects, was organized to supply such films at low cost to universities.[166]

The difficulties facing the designer of equipment for x-ray cinematography are reviewed by Roswell.[167]

Lucas[168] described and demonstrated his ultra-violet microscope at the New York meeting of the Society in 1930. Its applications to the study of biological and medical specimens were reviewed.

No cutting or staining of specimens is required when taking photographs of various sectional planes of the specimen.

C. Television

At a test made on February 12th, in the General Electric Laboratories, the features of a professor of the University of Leipsig, Ger-

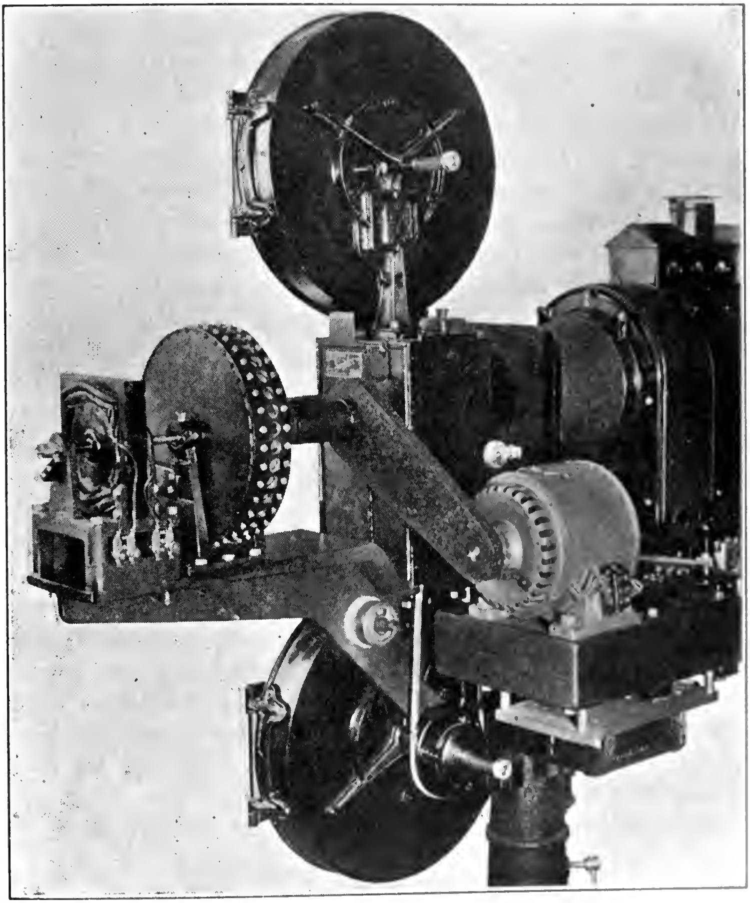

FIG. 6. Multiplex television projector.
(Reproduced by courtesy *Electronics*, N. Y., and Gramophone Co., Ltd., Hayes, England.)

many, were recognized by his friends as televised across the Atlantic ocean from Schenectady. According to the same article, progress

has been reported in the making of motion pictures of televised images.[169] About 1000 television sets are reported to be in use in the United States.[170]

Jenkins[171] has suggested a scanning screen for television composed of a plurality of cells, each actuated by its own shutter, composed of aluminum foil and controlled electrostatically by means of a synchronous commutator.

A motion picture film was used by Sanabria at Chicago in demonstrating the projection of a televised image on a screen 10 feet square.[172]

Ives has made further progress with his television experiments and has found that scanning by purple light gives better reproduction of image tones. Potassium photo-cells sensitive to the blue component of the purple light were used in conjunction with caesium cells for the red.[173] Ives has also constructed a three-channel system in which prisms, placed over the holes in a scanning disk, direct the incident light into three photoelectric cells. The three sets of signals are transmitted over three channels to a triple electrode neon lamp placed behind a viewing disk also provided with prisms over its apertures. An image of 13,000 elements is thus produced.[174] Good telephotographs contain about 250,000 elements, however, and according to Gannett[175] it is quite impractical under present conditions to radio-broadcast such pictures as it would require a frequency band 4 million cycles wide, the equivalent to 400 ordinary broadcast channels. Such a band would mean nearly complete monopoly of present transmitting channels.

A new multiplex system of television was introduced in England recently which uses a standard motion picture projector for transmission of pictures (Fig. 6). Five transmission channels are employed, each transmitting one-fifth of the picture. Much more light is therefore claimed to be available to illuminate the receiver screen, which may be full size.[176]

Two patents dealing with television methods were noted.[177]

D. General Recording and Miscellaneous Uses

An apparatus has been devised by Withrow and Boyd[178] which makes possible simultaneous flame and pressure studies by photography of individual explosions in a gasoline engine. The results indicate that the phenomenon of knock in the engine is due to a many-fold increase in the rate of inflammation within the latter

portion of the charge. The flame pictures were made on a constantly moving film through a quartz window in the cylinder head.

Winzenberg[179] has described a new camera of German design, capable of speeds up to 1500 exposures per second. The path of flight of a moving body such as an airplane may be determined accurately by use of a theodolite camera using motion picture film.[180] Slow motion pictures of the flight of trained eagles and falcons are being used in Germany to train glider pilots.[181]

Positions of the body during sleep have been recorded with a motion picture camera in an investigation conducted at the Mellon Institute. The camera is placed on a shelf near the bed and is actuated by a magnetic circuit breaker attached to the bed springs. A second exposure is made automatically one minute after the first by means of a supplementary mechanism.[182]

Only three patents were noted covering development in methods of general recording.[183]

V. COLOR CINEMATOGRAPHY

Comparatively few color motion pictures were released during the past six months. Nevertheless, laboratories equipped for color work continued to improve their processing equipment and devise additional refinements in their processes. With the marked improvement in the speed and color-sensitivity of panchromatic emulsions, coupled with improvements in optical systems, lighting equipment, and processing, it is likely that further refinements will be forthcoming in color print quality.

Clark[184] has prepared a list of 32 color processes which have been enjoying more or less commercial exploitation during the past year. The list is stated to be incomplete but some evidence of the interest being shown in color processes may be gained from an examination of it. Although it is evident from an inspection of the list that subtractive processes, requiring no change in projection equipment, have been the most popular, it is significant that a well-known producing organization demonstrated a three-color additive process at the meeting of the New York Section of the Society in December, 1930. Both originals and prints made by this process (Keller-Dorian) were shown. The film has horizontally embossed lenticulations and the copies were said to have been made by a new optical printing process.[185]

In order to reduce extra noise accompanying the running of a

sound color camera, Benson[186] has suggested that the camera be enclosed in an evacuated housing mounted on a resilient pad.

Macrae[187] offers the suggestion that the screen should be farther from the front seats for an all-color program than for an ordinary program. The extent of the "color field" is less than for a normal field of view since the sensitivity of the eye for color diminishes toward the periphery of the field of vision.

A general review of the processes of color photography was presented by Matthews[188] before the Fall, 1930, Meeting of the Society.

A limited number of patents were issued dealing with cameras and projectors for three-color additive processes.[189]

Four patents were noted disclosing methods of manufacturing multicolor screen films.[190] Lenticular screen processes were protected by two patents.[191] Three patents were issued covering two-color additive processes for cinematography.[192]

Brewster and Miller[193] have advanced suggestions based on experimental research regarding the most promising process for making three-color subtractive motion pictures.

Another application of the bi-pack method of exposure has been made in the Magnacolor process.[194] Two emulsions are used face to face. The front emulsion is blue-sensitive and is coated with a red dye on its surface. The back emulsion is panchromatic. Exposure is made through the support of the red dyed film. Details of processing, which are said to be worked out under patent protection, include exact registration in printing, application of the dyes in processing the positive, and machinery for developing and printing.

A historical résumé of the Kodachrome process has been published by Matthews,[195] showing that the first observations on the principles underlying this two-color process were made in 1910 by Capstaff.

As noted earlier in this report, the first industrial motion picture made by the Multicolor process was produced during the past six months under the title *Stepping Ahead*. A short account of a two-color subtractive process for animated cartoons with sound was published by Pander. The process was brought out by the Ufa Company in Germany.[196]

The Pilney system of color cinematography makes use of two laterally inverted images photographed side by side on a double width film which is folded down its length for projection purposes. Special double coated positive stock is used but technical details have not been published.[197]

Patent protection was granted on a limited number of processes for making motion pictures by subtractive methods.[198]

VI. AMATEUR CINEMATOGRAPHY

A. General Equipment and Uses

In a paper presented at the New York convention in October, 1930, Holslag[199] reviewed the status of home sound movies and concluded that only a modest distribution of sound equipment will be realized. Widespread use of such equipment is more likely to be found among a new group of users who are interested in it as an entertainment source rather than as a hobby.

Amateur Cameras.—Although amateur cinematography continued to enjoy increasing patronage during the past half year, there were comparatively few new pieces of equipment added to the present comprehensive list. In April, a new camera was announced which was claimed by its manufacturers to be the lightest camera using 16 mm. film yet offered to the market. When loaded with 100 feet of film, it weighs $3^1/_2$ pounds and is $8^3/_4$ in. high by 5 in. wide by about 2 in. thick. The frame is made of duralumin throughout.[200]

According to an announcement in a British publication,[201] a new combined camera and projector for amateur use has been developed. A row of pictures is exposed across a film, $4^1/_2$ inches wide. The film then moves upward to make room for another row in the reverse direction. A special reflector in the projector permits use of a smaller wattage bulb than is normally required in amateur projectors.

A few patents have been issued on amateur cameras.[202]

Projectors.—In spite of many reports that 16 mm. projectors, which may be used with sound-on-film records, are available for the market,[203] none have actually appeared. It is believed, however, that much progress has been made in this field and such equipment will doubtless be offered in the near future.

Additional types of equipment for use with disk records continued to be made available. In one type supplied by the Pacent Electric Company, the cabinet has been designed to hold both the turntable and projector. The amplifier is housed in a separate cabinet which also contains a loud-speaker unit.[204] Bell & Howell have announced a portable home movie equipment comprising a projector with a synchronized turntable, and also a radio set,[205] in the same cabinet.

A sound projector called the Animatophone is so designed that

the sound disk record rotates in a vertical plane and is connected directly to the projector motor shaft. Two speeds of rotation are possible, each maintained constant by a governor.[206] In the Ampro projector for 16 mm. film described by Shapiro,[207] two features are emphasized, *viz.*, a high speed intermittent and cylindrical shutter giving 64 interruptions per second, and the use of a 20-volt lamp which permits high screen illumination.

The Lytax projector uses a 250-watt, 50-volt lamp and is designed to take 16 mm. film.[208]

Several inexpensive projectors such as the Kodatoy, the Movector, *etc.*, have been marketed, intended primarily as toys for children.

Projectors and projection accessories were protected by several patents.[209]

Accessories.—The demand for more light for the projection of amateur films has been answered by the introduction of several improved types of lamps. At the New York meeting of the Society last October, Roper and Wood[210] reported the results of illumination measurements on lamps of low voltage. The advantages of the 20-volt lamp are obvious, both for spherical and aspheric condenser systems, a gain of 25 per cent in screen illumination being shown over 50-volt lamps of the same wattage. More recently, a 375-watt, 75-volt lamp was made available, which is still a greater improvement over the previously used types.[211]

Two recorders for making records to be used in conjunction with amateur projectors have been made available on the English market. The Kingston can be used only for direct acoustic recording but the Cairmor may be used for either acoustic or electrical recording of 6, 8, or 10 in. records.[212]

A special microphone used with the Filmophone projector enables the operator to make running comments through the loud speaker while the film is being shown. A synchronized disk is used which may be disconnected while the microphone is being used.[213]

Only a limited number of patents were issued noting improvements in 16 mm. accessories.[214]

Films and Film Processing.—Working instructions for the reversal of 16 mm. ciné film have been published by Gibbs.[215] At the Congress of German Broadcasters held in Vienna last fall, sound records on paper were shown for playing in conjunction with amateur cinema projection.[216] The sound is recorded on sensitized paper strips, 6 mm. wide, on which there is room for four sound tracks.

Three hundred meters require 40 minutes for reproduction. The record is of the variable width type and may be printed either photographically or mechanically on paper. Sound is reproduced by light reflected from the paper.

Three patents were noted which were related to 16 mm. film processing.[217] One patent was issued on a method of titling films.[218]

B. *Amateur Color Processes*

Apparatus for photographing growing plants in their natural colors has been described by Ricker.[219] Kodacolor film was used. For stop motion pictures, the camera and lights are controlled automatically by means of a timed contact disk, which, through a relay, operates a master switch that turns on the light and starts the camera.

One patent has been issued for making component color records on film narrower than 35 mm. intended for additive synthesis[220] and three patents were noted covering processes using lenticulated films.[221]

VII. STATISTICS

There are a total of 75 theaters in the U. S. Army camps and posts in the United States, of which 58 were equipped for sound pictures during 1930. About 17,000 performances are given yearly and the average house seats 400 persons.[222] According to data supplied by the Motion Picture Division of the U. S. Department of Commerce, there are a total of 62,365 theaters in the world, as of December, 1930, of which 19,894 had been equipped for sound picture projection. A later bulletin from the Bureau reported that there are approximately 7720 theaters wired for sound in Europe exclusive of Soviet Russia. There were 1320 theaters equipped during the last three months of 1930.[223]

Europe now has 33,870 motion picture theaters, representing an increase of 11,445 houses since 1926, seating 5,283,000 persons.[224] North and Golden[225] reported at the Fall, 1930, Meeting of the Society on equipment, installations, and general conditions existing in the industry abroad. At this meeting, Irby[226] gave an excellent summary of the patent situation, past and present, here and abroad.

A preliminary survey made by the Motion Picture Division of the U. S. Department of Commerce indicated that there were over 2000 concerns in the United States using motion pictures for business purposes. Further effort is being made by the Bureau to help

formulate plans for the most effective use of films, as well as to increase the distribution of available films.[227]

Cameramen in the East were paid over $800,000 for their services during 1930. Studio cameramen received $161,980, and $26,543 for overtime work.[228]

Film exports fell off slightly for the year 1930, as reported by Golden,[229] compared with 1929, although the actual valuation increased. Footage and valuation were as follows:

1930—274,351,000 linear feet valued at $8,118,000
1929—282,215,000 linear feet valued at $7,622,000

Of the total footage exported, 186,436,000 feet or 67 per cent represented sound pictures. There were 261,995,000 feet of positive film and 12,355,000 feet of negative film exported during 1930, compared with 273,772,000 feet of positive and 8,443,000 feet of negative during 1929 (an abnormal year due to the introduction of sound film). Of the total negative footage exported, 8,190,000 or about 61 per cent constituted sound films. From the figures given for negative film exports, it is seen that there was an increase for 1930 over 1929 of about 50 per cent. Golden considers that this indicates that more positive film is being printed abroad than in previous years.

Domestic sound picture equipment sales for 1930 totalled $32,635,000 according to *Electronics*,[230] and export sales amounted to $8,250,000, which made the total equipment sales equal $40,885,000. This same authority estimated that $192,000,000 was paid out by the motion picture industry during 1930 compared with $180,864,000 in 1929.

Under the five-year plan of the Soviet Union, it is expected that there will be approximately 52,000 theaters established by October, 1933. This will include 24,000 regular cinemas, 19,000 school theaters in Russia proper, and 9000 in the Ukraine.[231] Up to April, 1931, 296 Italian theaters had been equipped with sound film reproduction apparatus.[232]

A member of this committee, residing in Bombay, reported that there had been 14 new sound installations made in Indian theaters since the previous report, so that there are now 42 theaters equipped for sound pictures. Three companies are producing sound pictures, chiefly short subjects. A ten-reel sound picture feature was completed by the Imperial Film Company, Bombay, for release in

March, 1931. Sound pictures are reported to be very popular among Indian audiences.

Australia has 641 theaters wired for sound, of which 136 houses are equipped for disk reproduction only. As an indication of the rapid progress made in recent months, it is estimated that 95 per cent of the equipment was contracted for during the past year.[233]

VIII. PUBLICATIONS AND NEW BOOKS

A significant business transaction relative to trade publications in the United States occurred late in the year 1930 when the Quigley Publishing Company took over the publication of *Exhibitors Herald-World* and *Exhibitors Daily Review and Motion Pictures Today.* These two journals were discontinued as well as *Motion Picture News* (published for many years by the Quigley Publishing Co.), and beginning January 1, 1931, the following new journals were started: *Motion Picture Herald* (weekly), and *Motion Picture Daily.* The first number of a new French technical journal devoted to the motion picture industry appeared in October, 1930, under the name *La Technique Cinematographique.*

New books which have appeared are as follows:

1. *Kinematograph Yearbook 1931,* Kinematograph Publications, Ltd., London.
2. *The British Journal Photographic Almanac, 1931,* Greenwood & Co., Ltd., London.
3. *Soviet Photo Almanac,* edited by Soviet Photo, Ogonyok, Ltd., Moscow.
4. *General Annual of Cinematography* (*Annuaire Général de la Cinematographie 1930–1931*), Ciné Magazine, Paris.
5. *Publications from the Scientific Laboratory, Agfa, Photographic Division* (*Veröffentlichungen des wissenschaftlichen Zentral Laboratoriums Agfa: Photographischen Abteilung*), by I. G. Farbenindustrie Aktiengesellschaft, S. Hirzel, Leipsig.
6. *Photogrammetry and Aerial Surveying* (*Photogrammetrie und Luftbildwesen*), by R. Hugershoff, J. Springer, Vienna. This is Vol. VII of *Handbuch der wissenschaftlichen und angewandten Photographie,* edited by A. Hay.
7. *The Manufacture of Photographic Plates, Films, and Papers* (*Der Fabrikation des Photographischen Platten, Filme, und Papiere*), by J. M. Eder and F. Wentzel; *The Use of Photographic Plates, Films, and Papers* (*Der Verarbeitungen der Photographischen Platten, Filme, und Papiere*), by J. M. Eder, Luppo-Cramer, M. Andresen and A. Tanzen. These are Vol. 3, Pts. 1 and 2, respectively, of the 6th Edition of *Ausführliches Handbuch der Photographie.* W. Knapp, Halle.
8. *Photography—Its Principles and Practice,* by C. B. Neblette, Van Nostrand, New York, 2nd Edition.
9. *The Talkies,* by A. E. Krows, H. Holt & Co., New York, N. Y.
10. *The Talkies,* by Crosley Lockwood and Son, London.

11. *Sound*, by E. G. Richardson, Arnold & Co., London.

12. *Panchromatic Photography, Photo-Miniature No. 203*, edited by J. A. Tennant, Tennant & Ward, New York, N. Y.

13. *Basic Photography*, U. S. Air Corps Training Normal, War Department, Washington, D. C.

14. *The Construction and Equipment of Chemical Laboratories*, edited by the National Research Council, Chemical Foundation, Inc., New York.

15. *Theory and Practice of Hypersensitizing* (*Der Theorie und Praxis der Hypersensibilisierung*), by K. Jacobsohn, Union Deutsche Verlags., Berlin.

16. *Photographic Cells and Their Applications*, by J. S. Anderson, editor, Phys. & Opt. Soc., London.

17. *Sound Pictures: Principles and Practice of Their Production and Exhibition* (*Der Tonfilm: Grundlagen und Praxis seiner Aufnahme und Wiedergabe*), Vol. 4, H. Umbehr, editor Verlag der Lichtbildbühne, Berlin.

18. *Acoustics*, by G. W. Stewart and R. B. Lindsay, Van Nostrand Co., New York, N. Y.

19. *The Practice of Color Photography* (*Der Praxis der Farbenphotographie*), by E. Konig and K. Jacobsohn, Union Deutsche Verlags, Berlin.

20. *Color Photography*, by F. R. Newens, Blackie & Son, London.

21. *Visual Aids in Education*, by J. J. Weber, Valparaiso University, Valparaiso, Ind.

22. *Fundamentals of Television*, by T. W. Benson, Mancall Publishing Corp., New York, N. Y.

23. *George Eastman*, by C. W. Ackermann, Houghton, Mifflin Co., New York, N. Y.

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[184] *Phot. J. (Supp.)*, **71** (Apr., 1931), p. 22.
[185] *J. Soc. Mot. Pict. Eng.*, **16** (Feb., 1931), p. 179.
[186] *Kinemat. Weekly*, **162** (Aug. 14, 1930), p. 63.
[187] *Kinemat. Weekly*, **162**.(Aug. 7, 1930), p. 55.
[188] *J. Soc. Mot. Pict. Eng.*, **16** (Feb., 1931), p. 188.
[189] *U. S. Pat.* 1,778,754; *Brit. Pats.* 334,708; 335,310; *Ger. Pats.* 494,753; 500,265; *Fr. Pats.* 676,016; 679,567; 679,568.
[190] *Brit. Pats.* 333,865; 334,243; 334,265; 335,899.
[191] *U. S. Pat.* 1,777,954; *Ger. Pats.* 498,027; 498,480.
[192] *Brit. Pat.* 339,651; *Ger. Pats.* 495,686; 498,709.
[193] *J. Soc. Mot. Pict. Eng.*, **16** (Jan., 1931), p. 49.
[194] *Amer. Cinemat.*, **11** (Mar., 1931), p. 20.
[195] *J. Soc. Mot. Pict. Eng.*, **15** (Nov., 1930,) p. 624.
[196] *Phot. Korr.*, **66** (Oct., 1930), p. 271.
[197] *Kinemat. Weekly*, **163** (Sept. 11, 1930), p. 45.
[198] *U. S. Pats.* 1,775,938; 1,778,139; 1,787,808; *Brit. Pats.* 333,931; 333,932; 333,933; 334,004; *Fr. Pat.* 683,707.
[199] *J. Soc. Mot. Pict. Eng.*, **16** (Jan., 1931), p. 67.
[200] *Radio Retailing*, **13** (Apr., 1931), p. 56.
[201] *Bioscope (Mod. Cinema Technique)*, **86** (Feb. 4, 1931), p. i.
[202] *U. S. Pats.* 1,762,939; 1,779,468; 1,781,937; *Ger. Pats.* 500,357; 505,591; 505,592; 505,656; 505,657; *Fr. Pat.* 678,722.
[203] *Phot. Dealer* (Jan., 1931), p. 20; also *Film Daily*, **55** (Mar. 12, 1931), p. 12.
[204] *Electronics*, **2** (Mar., 1931), p. 566.
[205] *Photo Era*, **66** (Jan., 1931), p. 53.
[206] *Internat. Phot.*, **2** (Dec., 1930), p. 33.
[207] *J. Soc. Mot. Pict. Eng.*, **15** (Nov., 1930), p. 598.
[208] *Phot. Ind.*, **28** (Oct. 22, 1930).
[209] *U. S. Pat.* 1,774,097; *Ger. Pats.* 493,646; 501,421; 503,675; 505,654; *Fr. Pat.* 679,515.
[210] *J. Soc. Mot. Pict. Eng.*, **15** (Dec., 1930), p. 824.
[211] *Mot. Pict. Projectionist*, **4** (Mar., 1931), p. 29.
[212] *Amat. Phot.*, **71** (Feb. 4, 1931), p. 107.
[213] *Mot. Pict. Daily*, **28** (Dec. 29, 1930), p. 4.
[214] *U. S. Pats.* 1,763,231; 1,784,281; *Brit. Pats.* 334,082; 339,585; *Fr. Pats.* 678,427; 682,369; *Ger. Pat.* 505,969.
[215] *Brit. J. Phot.*, **77** (Aug. 8, 1930), p. 475.

[216] *Reports, Mot. Pict. Div. U. S. Dept. Commerce* (Oct. 29, 1930).

[217] *U. S. Pats.* 1,762,936; 1,780,025; *Brit. Pat.* 337,472.

[218] *U. S. Pat.* 1,787,198.

[219] *Amer. Phot.*, **24** (July, 1930), p. 352.

[220] *Brit. Pat.* 335,432.

[221] *U. S. Pats.* 1,762,143; 1,762,932; 1,762,933.

[222] *Ex. Herald-World*, **101** (Oct. 11, 1930), p. 35.

[223] *Bull. No.* **46-T**, *Mot. Pict. Div., U. S. Dept. Commerce* (Mar. 24, 1931); also *ibid.* (Feb. 27, 1931).

[224] *Ex. Daily Review & Mot. Pict. Today*, **28** (Nov. 18, 1930), p. 1.

[225] *J. Soc. Mot. Pict. Eng.*, **15** (Dec., 1930), p. 749.

[226] *J. Soc. Mot. Pict. Eng.*, **15** (Dec., 1930), p. 739.

[227] *Reports, Mot. Pict. Div., U. S. Dept. Commerce* (Jan. 7, 1931).

[228] *Film Daily*, **55** (Jan. 9, 1931), p. 1.

[229] *Bull. Mot. Pict. Div., U. S. Dept. Commerce* (Feb. 7, 1931).

[230] *Electronics*, **2** (Mar., 1931), p. 538.

[231] *Film Daily*, **54** (Oct. 1, 1930), p. 1.

[232] *Mot. Pict. Herald*, **103**, Sect. 2 (May 2, 1931), p. 76.

[233] *Reports, Mot. Pict. Div., U. S. Dept. Commerce* (Feb. 4, 1931).

APPENDIX

MOTION PICTURES IN JAPAN*

In Japan as in other countries of the world, the advent of the motion picture marked the beginning of the gradual decline of the legitimate theater as the principal source of entertainment for the masses. Motion pictures today are a universally popular form of entertainment for the Japanese people.

In the course of years during which Japan has been assuming attributes of western civilization, the first requirements in manufactured products, which were demanded by the various steps of its progress in that direction, were brought from abroad. But Japan kept industrially abreast of its westernization, and with the imported article as a model, gradually supplied with home products each successive demand. Thus it was only in the regular course of events that Japan began to produce motion picture films in 1897, just two years after the importation of the first foreign reel. Possessing a theater old in tradition and highly developed artistically, it was only the mechanical features of motion picture production that presented problems which, however, were soon solved with varying degrees of success

Today the combined capital of the motion picture producing companies in Japan is estimated at $125,000,000. Of this amount only $8,310,000 represents the capital of incorporated enterprises, and $116,690,000 approximately that of private concerns.

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The larger incorporated motion picture producing companies in Japan are:

Silent Films	*Sound Pictures*
The Shochiku Cinematograph Co.	The Mina Talkie Producing Co.
The Nikkatsu Co. (Ltd.)	The Eastphone Talkie Co.
The Taikoku Kinema Theatrical Co.	Teikine Motion Picture Co. (a subsidiary of the Shochiku)
The Makino Kinema Co.	
The Kawai Motion Picture Co.	

The Shochiku enterprise produces about 100 feature films a year, and the Nikkatsu Company about 80. Production costs are given as approximately \$2.50 per foot of film, or about \$10,000 per average film. It is readily apparent that Japanese produced motion pictures are not of as high a standard in production to even the lesser American major films.

Salaries of actors and directors are not generally known. Remuneration is on a monthly basis, with a small bonus payable at the completion of the picture. A leading actor or actress will take part in four or five pictures annually. It is stated that the salary of leading motion picture actors in Japan rarely exceeds \$500 to \$750 per month.

Prominent stars appearing in what may be termed the romantic historical school of Japanese drama, "Kabuki," receive salaries ten times as large as those paid to motion picture artists. Only about 20 per cent of motion picture actors have been drawn from the legitimate theater.

Police regulations have limited the length of motion picture programs in Japan. A standard length picture contains about 5480 meters.

Distribution.—Japanese films are produced primarily for Japanese consumption. The Shochiku Co. about a year ago established the World Film Distributing Co. and obtained a marketing agreement with a German firm to distribute Japanese films in Germany and 17 other European countries. Actual exporting, however, has not yet been undertaken. It is intended to limit films to classic and historical subjects. At present about 20 or 30 motion pictures are sent from Japan to Germany annually to be arranged for synchronized and sound display. Exported films have English titles. The larger Japanese passenger ships all show Japanese films, and about 50 pictures annually find a market in South America for Japanese immigrants.

The market for American "all-talkie," sound and synchronized motion pictures in Japan is not as extended as that for the silent films. When sound pictures of various forms first made their appearance in Japan, they were accepted as a novelty. But owing to language difficulties the 100 per cent American talking pictures began to diminish in popularity. The rapid action and intense dramatic situation of the silent films sustained interest even where the titles were not intelligible. These features are necessarily slowed down in all-talking pictures which depend largely on the dialog which is in English, and as it is not comprehended by the Japanese audience, attention and interest flag.

Types of Sound Picture Preferred in Japan.—All-talking versions of foreign motion picture films have not been especially well received in Japan because they cannot be understood properly or appreciated by Japanese audiences. Talking pictures were at first a novelty but audiences have since become tired of viewing a succession of scenes which, in many instances, are devoid of action

and depend entirely on dialog to explain certain situations and to develop the story.

It would appear, therefore, that sound pictures in synchronized form, that is, pictures with musical scores, sound effects, and occasional song numbers with sub-titles retained are more suitable for Japanese audiences, but since the present-day synchronized version of a picture is merely a revision of the original all-talking negative, the movement of the story still remains slow, and from the Japanese point of view, often uninteresting. The chief objection to the use of sound equipment is the Japanese custom of having an interpreter. The combination of the two sounds makes it impossible for either the interpreter or the machine to be heard distinctly, and until this problem is solved, the future of the talking motion picture in Japan is dubious.

Several foreign distributors in Kobe have recently imported further prints of their previously released and popular silent films because so many of the present-day sound films are considered unsuitable for distribution here. Several of the local independent Japanese distributors have recently imported a considerable number of Continental silent films to meet this demand for well-defined stories having speed and action, hoping thereby to combat the present falling off in theater admission.

Japanese audiences were able to follow more readily the action of the story in the days of silent pictures as the tendency at that time was to eliminate sub-titles as much as possible and to explain the story by action rather than by words. In this connection the importance of the language barrier should not be forgotten. The success of one American sound picture was due to the fact that the picture was originally made as a silent film, and the synchronized musical score with sound effects was added at a later date, which robbed the picture of none of its action but helped its entertainment value. Plans are now under way to produce locally-made pictures with dialog, which may help audiences to become sound-minded, and thereby react favorably on the importation of synchronized pictures, while at the same time it should popularize sound pictures in the smaller towns and villages, whereas at present this type of entertainment is confined to the principal cities of the country.

Motion Picture Theaters.—Motion picture theaters of all sizes and classes in Japan and its colonies in 1926 numbered 1097. In 1930 this number had increased to 1327. In 1912 there were only 170 theaters. Of the 1327 registered motion picture theaters 21 have sound installation, all of American make. There are a number of portable outfits for temporary installation. The owners of these ambulate among the theaters in the smaller country towns. Up to the present there have been produced only ten talking pictures in Japan.

The following table shows the attendance at motion picture theaters and other forms of stage entertainment for the four years 1926–30, inclusive.

	Movie Halls	*Other Performances*	*Total*
1926	117,805,000	35,929,000	153,735,000
1927	127,184,000	37,220,000	164,404,000
1928	140,263,000	41,016,000	181,279,000
1929	152,439,000	40,055,000	192,494,000

These figures have been compiled by the Police Affairs Bureau of the Ministry of Home Affairs.

Briefly summarized, the position of sound pictures in Japan today is as follows: (1) dialog pictures in most instances are not suitable for the Japanese market; (2) synchronized pictures with too many song numbers, which would have a tendency to slow up the action of the story, are also unsuitable; (3) if practicable, the production of a separate negative for each picture produced for foreign audiences would be an asset, as more speed and action would be inserted into the picture.

COMMITTEE ACTIVITIES

REPORT OF THE COLOR COMMITTEE*

No radical changes in the production of color prints for motion pictures have come to the attention of this Committee. New variations of well-known principles are being tried and used. The making of prints in large quantities with but little advance in cost over black-and-white prints appears to be the goal to seek.

In connection with making negatives that do not require delicate and special cameras, it may be said that this stage of the art has been advanced by the use of bi-pack negatives. All the makers of studio cameras now adapt their cameras for this kind of work.

Processes not previously listed include:

Coloratura.—This is the process of Pathé Exchange at Bound Brook, N. J. Negatives are made by the bi-pack method. Prints are made on double-sided film and are dye-toned on one side and metallic-toned on the other. The double-sided film, having two developed, silver images is first treated on one side to make it dye-selective and from then on the film is totally submerged to receive both colors, the blue-green tone on one side and red dye on the opposite side, neither color going to the wrong side. The film is treated by machinery so that the work is completed in a single trip of the film through the device.

Thomas Color.—A single strip negative is used, on which the exposures are made in pairs. The projector is likewise equipped to project two images at once. Black-and-white prints are used and color filters supply the color. So far, the method as stated would cover the first Technicolor films. The Thomas method differs from Technicolor in that the pairs are in sequence whereas in the early Technicolor additive system the pairs were four frames apart.

Graphy Color.—Graphy Color claims to operate under the patent application of Luigi Cristiani, an Italian. Sheets of Cellophane or similar material, such as Celite, are dyed magenta, yellow, and blue-

* Presented at the Spring, 1931, Meeting, at Hollywood, Calif.

green and sensitized with bichromate. A sheet of each kind is printed by arc-light under the appropriate three-color separation negative until the faint positive print-out image has attained the proper density. The sheets are then soaked in warm water and developed in dilute acid permanganate solution, which discharges the dyes roughly in inverse ratio to the exposure and produces positive images in three colors. The three sheets, after clearing and washing, are superimposed on gelatin-coated paper and cemented together with gelatin solution, producing a three-color print with either a glossy or matte surface.

Gilmore Color.—This system is said to be additive. Two images are taken in pairs side by side on 35 mm. film by turning the images to lie lengthwise on the film. A projector using color filters then turns and registers the two images on the screen by means of prisms. (*U. S. Pat.* 1,262,954, F. E. Ives, April 16, 1918.)

Magnacolor.—This name has been adopted for a color system by the Consolidated Laboratories. This concern is licensed by the owners of the Prizma patents and is following the system of using bi-packs for the negatives and double-sided film for the positives. One side of the double-sided film is colored blue by an iron solution and the opposite side is colored red by uranium. Operating under the Mason patent, each side is colored without danger of having the color solutions attack more than one side at a time by floating the film across the liquid coloring baths. Single-solution toning baths are used.

Rotocolor.—Harold Muller of New York is the inventor of a color process, Rotocolor, which is said to involve a shutter device attachable to a standard projector and which is easily removable, permitting switching between black and white. (*Film Daily*, April 12, 1931.)

Opticolor.—The Opticolor Corporation has been formed in New York with the studio at Long Island operating a three-color additive process. No details are given as to the system used. (*Motion Picture Herald*, April 11, 1931.)

Spectrocolor.—A German Company has been formed to exploit a color process under the name of "Spectrocolor," an additive system. The company claims control of about forty patents covering the process. (*Film Daily*, March 24, 1931.)

Multicolor.—In a process for producing color images, fixed silver images are treated with a basic dye bath and then with a uranium toning and mordanting bath. Films having color component images

on opposite sides are simultaneously printed in register from color component negatives. The printed positive is developed, fixed, and washed and the side bearing the images printed from the orange-red negative is toned blue by the application of an iron toning solution to that side only. The film is then passed through successive baths containing (1) water; (2) a basic red dye; (3) water; (4) a uranium toning and mordanting solution; (5) water; (6) hypo; (7) water; and dried. (*Brit. Patent* 339,323.)

ADDITIONAL NOTES

Lucas, Mobius, and Noack have patented the plan, for use with additive projection, of having the red and green pictures taken side by side and the blue picture below, whereby the red and green are shown twice as often as the blue during projection. (*Ger. Patent* 491,049.)

F. Wulff and Company make three-color prints by first making a blue picture with blue-print paper and then, by imbibition, transferring the yellow and magenta colors to the blue print. (*Ger. Patent* 488,968.)

An improvement, said to be quite great in additive projection means for color, results from toning the prints and projecting by a rotating two-color disk. (*Ger. Patents* 499,012 and 499,013, F. Lierg and L. Pokorny.)

W. Eibfelt has taken out a German patent for making a film with an emulsion that contains leuco bases of red, green, and yellow. The colorless dyes are dissolved in alcohol and added to a batch of emulsion. Each color is separately mixed into one lot of emulsion. Four separated lots of emulsion, three with dyes and one without dye, are then joined into one batch. The mixed batch is then coated on the base in one layer as usual.

The silver image that is exposed and developed in this emulsion is reduced to iodide or ferro copper which oxidizes the leuco colors and which are thereby mordanted. The unmordanted dyes are then washed from the emulsion. (*Ger. Patent* 400,350.)

R. Ruth patents the idea of using screen plates or autochrome grain plates for motion pictures by adding a panchromatic emulsion to the opposite side of the film, so that pictures are made on both emulsions, in order to obtain a combination picture in which one picture is a thin black-and-white and the other a very strong color picture. The object of this is to obviate graininess. (*Ger. Patent* 489,794.)

Much activity is apparent in the field of making motion pictures in color by the Keller-Dorian system. Usually an engraved wheel pressed into contact with the celluloid in the heated condition forms the minute lenses on the base.

The Eastman Kodak Co. makes fluted lenses in lines. The lines are produced by winding a mandrel with fine copper wire, which is electroplated with copper. The inside of the wire spool is covered with nickel and a bearing is formed. The copper covering of small wires is etched away leaving a nickel drum with a perfect formation of surfaces for impressing the celluloid base with fine lines. (*Ger. Patent* 495,845; *Fr. Patent* 682,380.)

The Eastman Kodak Co. proposes covering a Kodacolor base with a light absorbing filter color that is easily bleached, in order to prevent halation. (*Brit. Patent* 312,992.)

Lumière is evidently endeavoring to find an alternate way by means of which autochromes can more readily be produced. Silk strands are formed into blocks of the recurring three colors, which are impregnated with wax or paraffin. Thin sheets are cut on a microtome and the silk mosaic is applied to glass or film, the wax or paraffin is removed, and the interstices filled with black carbon dust. (*Photo. Korr.*, No. 1, Vol. **66**, 1930).

A motion-picture film has the "film base printed with a foundation or matrix consisting of a half-million minute red, green, and blue-violet squares to every square inch of film," says the *London Daily Mail* of May 20, 1931. This film was shown to the Royal Photographic Society.

NEW COLOR SYSTEM

Regular panchromatic motion picture negative is exposed in a standard type of motion picture camera. The objective is made so that a color line-screen of two, three, or four colors in lines or in recurring units may be inserted in the system. This system brings the images to focus on the screen-plate, and the image and lines are in focus at the film plane. By this means the line-screen is not in contact with the film.

On the edge of the screen-plate is a clear line which photographs at each exposure of the image. This gives a definite registration mark for any particular picture. From this negative, positives may be printed by any means that also includes the registration line or mark.

The projector is equipped with the same type of lens that is used

in the camera. It also has a photo light arrangement to hold the registration line of the line-screen in the projector in registration with the marks on the positive.

The producers are required to make no change in the photographing other than to use the lenses. The makers of sound equipment would be required to equip projectors with the electrical registration means and projecting objectives. No changes will be involved in the cost of making negatives and positives, and sound remains as it is now. (By W. V. D. KELLEY.)

MORENO CAMERA

The outstanding difference between the Moreno camera and the present-day standard camera is that the Moreno camera entails continuous motion. The film passes through the camera at a uniform speed with no intermittent motion of the film or any moving part of the camera. A stationary image on each frame is obtained by distributing the light transmitted by the photographic lens over a given area of constantly moving film by means of a revolving rectifying optical system of thin prisms traveling at a linear velocity equal to that of the film. This is an octagonal glass wheel with each face carrying a plano-convex lens element.

The camera has a practical built-in exposure meter that is automatic in its action. The meter is located at the rear of the camera proper.

INTER-SOCIETY COLOR COUNCIL

President Crabtree appointed Ralph M. Evans and H. W. Moyse as delegates representing the Society of Motion Picture Engineers to the Inter-Society Color Council, which meeting was reported to the S. M. P. E. by Mr. Evans as follows:

On February 26, 1931, about forty men representing fourteen societies met in the Museum of Science and Industry in New York, N. Y., in response to a call for such a meeting by the Optical Society of America. Mr. L. A. Jones acted as chairman and Mr. M. Rea Paul as secretary.

Mr. Irwin Priest of the Bureau of Standards, opening the meeting, spoke at some length on the need for a more definite color nomenclature and methods of specifying colors where a lengthy scientific specification is too troublesome and expensive. To quote from the minutes of the meeting:

"Following Mr. Priest's remarks a rather lengthy informal discussion was conducted in which practically everyone present took part. In the beginning there seemed to be a rather wide diversity of opinion as to the best mode of procedure to be followed in organizing an inter-society committee or council. As the discussion progressed, however, the ideas began to crystallize and finally almost complete unanimity of opinion was reached and the following resolutions were passed:

"(1) *Resolved:* It is the sense of this meeting that an 'Inter-Society Color Council' be formed, composed of delegates from national societies and associations interested in the standardization, description, and specification of color.

"(2) *Resolved:* It is the sense of this meeting that the delegates at this conference report back to their societies and associations the resolution which was adopted at this meeting, and request the several organizations to appoint their delegates and send notification of such appointments to the chairman of this meeting, who will be expected to call the first meeting of the Inter-Society Color Council, at which time the Council will form a permanent organization.

"(3) *Resolved:* It is the sense of this meeting that the secretary be instructed to send minutes of this meeting to all delegates appointed, and also to each society and association invited to send delegates but which were not represented, and extend at the same time to all societies and associations invited but not represented, an invitation to send delegates to the first meeting of the Inter-Society Color Council.

"(4) *Resolved:* It is the sense of this meeting that the several societies and associations be advised that they may appoint as many delegates to the Inter-Society Color Council as desired, but that each organization represented on the Council shall have only one vote.

"(5) *Resolved:* It is the sense of this meeting that the present chairman be, and hereby is, authorized and empowered to call the first meeting of the delegates to be appointed to the Inter-Society Color Council, said first meeting to be called at such time and place as may, in his discretion and that of the secretary, seem most suitable."

PATENTS RELATING TO ART OF COLOR PHOTOGRAPHY ISSUED IN 1930

1,742,543. **Colored-Picture Transmission.** HERBERT E. IVES, Jan. 7, 1930. (Class 178-5.) Electrical transmission of colored pictures. It is proposed to prepare a set of transparent monochrome color records which are scanned with a source of light and transmitted as a single operation as color records to a distant

point. After the transmission to the distant point, the records are reproduced as line images of the original and utilized to produce the original picture in colors.

1,742,680. **Method of Making Motion Pictures.** PIERRE ARTIGUE, Jan. 7, 1930. (Class 88-16.) Relating to the well-known glass shot art, in which it is proposed to stain a part of one or more of the screens with a photographically less actinic light filter color than the general illumination.

1,742,943. **Automatic Control for Photographic Printing Exposures.** CLIFTON M. TUTTLE AND HERBERT E. WHITE, Jan. 7, 1930. Assigned to Eastman Kodak Company. (Class 95-90.5.)

1,745,107. **Animated Pictures in Relief.** RAFAEL MENDOZA, Jan. 28, 1930. (Class 88-16.4.) A system for exhibiting animated pictures of objects in relief. Two differently colored images are projected onto a screen in laterally displaced relation.

1,745,247. **Manufacturing Foils, Films, Ribbons, and the Like from Viscose and Similar Cellulose Solutions.** EMIL CZAPEK AND RICHARD WEINGAND, Jan. 28, 1930. (Class 18-57.)

1,746,330. **Color Photography.** JAMES G. ZIMMERMAN, Feb. 11, 1930. (Class 95-2.) A photographic printing blank having a plurality of light-sensitive areas presenting three colors, and in such a manner that the combination of any two of which colors will produce a color complementary to the third color.

1,746,584. **Apparatus for Taking Views and for the Reproduction of Cinematographic Films in Colors.** PAUL FOURNIER, Feb. 11, 1930. (Class 95-2.) An objective with a sensitive surface in image-receiving relation thereto is utilized. A multicolor diaphragm provided with dividing lines between color areas is interposed between the objective and sensitive surface.

1,749,278. **Optical System for Use in Photographic Color Processes.** CHAS. W. FREDERICK, Mar. 8, 1930. (Class 95-2.) *Claim 10:* "Complementary optical systems for use in the taking and projecting of color photographs by the use of photographic layers having associated therewith numerous microscopic image-forming elements and comprising two objectives of different focal lengths, each system including one objective and a polychromatic screen associated therewith, and one system including a weak supplemental lens in front of its rear focal plane by a distance less than ten per cent of the focal length of the system, the positions of the screens in the systems being such that the virtual images thereof are of the same size and have the same positions relative to the rear focal planes of the systems."

1,750,358. **Color Photography.** PIERRE ABEL RICHARD, Mar. 11, 1930. (Class 88-16.4.) *Claim 1:* "In the production of motion pictures in color, the steps of photographing the objects on a moving film which is goffered on its front face with a multitude of minute lenticular projections, while subjecting the light rays to the action of a polychrome filter so as to select the colors of the rays which reach the film and thereby form images in polychrome corresponding to the colors of the filter; and thereafter reproducing the polychrome images of the goffered film on a non-goffered film while the former is illuminated, and advancing the non-goffered film, for each image-space of the goffered film, a number of image-spaces equal to the number of color values of the polychrome filter, while masking said filter in such a way as to permit the light to pass through only one of its colored elements for each image on the non-goffered film, to obtain on said non-

goffered film a plurality of separate monochrome images of the polychrome image corresponding in number to the number of color values of said polychrome image."

1,751,220. **Light Filter.** ICHITARO SHOJI, Mar. 18, 1930. (Class 95-81.5.)

1,751,318. **Process for Obtaining Photographic Images.** EUGENE GAY, Mar. 18, 1930. (Class 95-7.) Relating to the obtaining of a positive violet-red image.

1,752,477. **Camera for Color Cinematography.** PERCY D. BREWSTER, April 1, 1930. (Class 88-16.4.) *Claim 1:* "In a color camera, the combination with a lens, a film-gate in the rear of the lens to support a negative film in position for exposure, a plane mirror extending between the lens and said film-gate and occupying a plane at an angle to the axis of the lens, said mirror having at least one light-passing opening, means for revolving the mirror in its own plane, a film-gate arranged to support a negative film in position to receive light reflected by the mirror, means for feeding films through the film-gates simultaneously step-by-step, a shutter for exposing both films at each period of rest thereof, and means for actuating the mirror, the shutter, and the film-feeding means in harmony with each other."

1,752,680. **Optical Means for Producing Color Cinematographic Pictures.** KARL MARTIN AND PAUL TIETZE. April 1, 1930. (Class 88-1.) "In a device of the class described, a ray-dividing device comprising a partly light-pervious mirror, a pair of objectives arranged upon axes perpendicular to one another and positioned so that one objective receives directly the rays reflected from said mirror, while the other objective receives directly the rays transmitted through said mirror, means for passing a film perpendicular at its midline to the plane of said mirror, and optical means for turning the rays from said objectives into parallel contiguous paths registering respectively with the two halves of said film."

1,753,140. **Multicolor Cinematograph and Other Films.** JOHN EDWARD THORNTON, April 1, 1930. (Class 88-16.4.) *Claim 1:* "A multi-color picture-positive having four component images in two half pictures and comprising two thin transparent supports of half thickness, one support bearing a half picture containing two component images, an image in one color upon each side of said support, and the other support bearing a half picture containing two component images, an image in one color upon each side of the other thin support, the two transparent supports being superimposed with the two half pictures assembled and disposed within one picture area and cemented together."

1,753,379. **Color Photography.** WILLIAM V. D. KELLEY, April 8, 1930. (Class 95-2.) *Claim 1:* A photographic process which consists in forming a latent image in a light-sensitized coating on one side of a transparent carrier, developing in acid diaminophenol, toning with an iron salt to a blue color and, after clearing with an aqueous bath of ammonium bromide and potassium bichromate, forming an image in the same coating and an image in a like coating on the other side of the transparent carrier and coloring said last formed images, one a magenta and the other a yellow, while preventing the coloring matter for one image from coming in contact with the other image."

1,754,323. **Color Projection Apparatus for Cinematographs.** REGINALD KILLICK, April 15, 1930. (Class 88-16.4.) Relating strictly to the apparatus.

1,757,852. **Color Screen.** CARL ALSTRUP AND VIGGO JENSEN, May 6, 1930. (Class 88-164.) "In an apparatus for producing pictures in natural

colors, a rotatable disk having a plurality of color filters and opposed shutter segments dividing the filters into two groups, one group being composed of red and orange filters and the other group of yellow, green, blue, and violet filters, the tangential lengths of the red and orange filters being greater than the length of the other filters in proportion to the optical effectiveness of the colors whereby the latter produce equal impressions upon the eye."

1,758,137. **Apparatus for Printing Reticulated Films.** RODOLPHE BERTHON, May 13, 1930. (Class 88-24.)

1,758,184. **Manufacture of Multicolor Cinematograph Films.** JOHN EDWARD THORNTON, May 13, 1930. (Class 95-2.) *Claim 2:* "The method of producing a multi-width, multi-layer cinematograph colloid film positive comprising coating a temporary re-inforcing backing with colored colloid arranged in a plurality of parallel strips, sensitizing the colloid, printing component images one at a time in a straight line across the multi-width film, severing the film into a plurality of strips of single-width, removing the paper re-inforcement, cementing the printed colored strips together in accurate register and adding a layer of waterproof varnish."

1,758,185. **Cinematograph Color Film and Method of Manufacture.** JOHN EDWARD THORNTON, May 13, 1930. (Class 95-2.) *Claim 1:* "The method of manufacturing a strip of film material which consists in coating a strip of celluloid with a thin layer of insoluble bichromated gelatin, applying thereto two strips of sensitized colloid, drying and shrinking the same, coating a strip of porous paper with a thin layer of soluble gelatin, drying and shrinking the same, damping the face of the two strips and laying one strip on the other to amalgamate them into a single strip of film material."

1,758,572. **Process of Producing Pictures Consisting of Dyes in Photographic Manner.** FRIEDRICH LIERG, May 13, 1930. (Class 95-6.)

1,758,768. **Multicolor Cinematograph and Other Film.** JOHN EDWARD THORNTON, May 13, 1930. (Class 95-2). *Claim 1:* "A double-width, multicolor, screen-mosaic picture positive comprising a double width film of transparent material, a color-mosaic screen in two colors covering each half width of the double-width film, an adhesive substratum between each color-screen and each half width of the film, and a half picture of negative character upon each half width of the film superimposed on its own color-screen."

1,758,769. **Multicolor Cinematograph and Other Film.** JOHN EDWARD THORNTON, May 13, 1930. (Class 95-2.)

1,758,977. **Reflecting Prism.** THOMAS W. ROLPH, May 20, 1930. (Class 88-1.) A prism so constructed as to reflect a light ray at least three times in the same plane.

1,759,914. **Method of Producing Film for Color Cinematography.** ALEXANDER PILNY, May 27, 1930. (Class 88-16.4.) *Claim 1:* "A method of producing film strips for cinematography which comprises splitting a series of images rectangularly and projecting them onto longitudinal parallel portions of a film strip by folding the strip longitudinally at right angles to present said portions for receiving the partial images."

1,761,361. **Control-Mechanism for Color Projecting Machines.** ANTON J. OBERG AND ROBERT R. STOEFEN, June 3, 1930. (Class 88-24.) Relating strictly to the construction of the projecting machine.

1,761,897. **Multicolor-Cinematographic and Other Film and Process of Making Same.** JOHN EDWARD THORNTON, June 3, 1930. (Class 95-2.) *Claim 1:* "A method of producing multi-colored cinematograph film positives upon double width transparent material of half standard thickness consisting in simultaneously coating one half width of the double width material with a sensitized colloid containing dye of one color and the other half width with a sensitized colloid containing dye of a different color, photographically printing on each half width a partial image, washing off the surplus colored colloid, recoating each half width of the support with a differently colored sensitized colloid, which also differs in color from the colors in the first coating, printing on each half width a second partial image in the same picture space as the first partial image, washing off the surplus colloid, dividing the strips longitudinally, superimposing the two divided strips with their partial images in register and cementing them together to produce a complete picture in four colors in a single picture area."

1,762,143. **Filter and Method of Preparing Same.** JOHN G. CAPSTAFF, June 10, 1930. (Class 95-81.5.) Method of manufacture of a filter and of applying a color solution to the surface of a transparent plate.

1,762,144. **Lens System for Color Photography.** HAROLD N. COX, June 10, 1930. (Class 88-1.)

1,762,932. **Projection System for Color Pictures.** JOSEPH MIHALYI, June 10, 1930. (Class 88-16.4.)

1,762,933. **Projection System for Color Pictures.** JOSEPH MIHALYI, June 10, 1930. (Class 88-16.4.)

1,764,083. **Color Guide.** WILLIAM J. MISKELLA, June 17, 1930. (Class 41-6.)

1,768,795. **Dye-Carrying Layer for Photographic Films and the Like.** SAMUEL E. SHEPPARD AND JAMES G. MCNALLY, July 1, 1930. (Class 95-9.)

1,768,812. **Method of Producing Light Effects.** WILLIAM J. WHITING, July 1, 1930. (Class 88-1.) *Claim 1:* The method of producing two coördinate differing visual effects which includes the steps of projecting upon an object objectively homogeneous as to color, a plurality of beams of subjectively similar light, said beams having an invisible spectral difference and substantially the same spectral center of gravity, said object having a spectral center of gravity different from that of the beams, whereby, when either beam strikes the object, its subjective color will change.

1,768,813. **Method of Increasing the Chroma of a Color.** WILLIAM J. WHITING, July 1, 1930. (Class 88-1.)

1,768,814. **Method of Reducing Glare and Dazzle of an Opposing Light.** WILLIAM J. WHITING, July 1, 1930 (Class 88-1.)

1,769,041. **Color Filter and Process of Manufacturing the Same** MERRILL W. SEYMOUR, July 1, 1930. (Class 95-81.5.)

1,769,940. **Manufacture of Light-Sensitive Films.** ULRICH DIEM-BERNET, July 8, 1930. (Class 95-9.) *Claim 1:* "A process for producing light-sensitive negative and positive films having no coating, which consists in incorporating sensitizing agents in the film mass of viscose during the manufacture of the film material."

1,771,029. **Motion Picture Film and Method of Producing.** JAKOB BURKHARDT, July 22, 1930. (Class 88-16.) This invention relates to third dimension pictures.

1,772,081. **Process and Apparatus for Treating Derivatives of Aqueous Cellulose Compounds for Use in Photographic and Its Allied Arts and Other Useful Purposes.** FREDERICK W. HOCHSTETTER, Aug. 5, 1930. (Class 91-69.)

1,772,622. **Motion Picture Color Photography.** PIERRE M. ARTIGUE. Aug. 12, 1930. (Class 88-16.4.) *Claim 1:* "The herein described method of coloring motion picture films which consists in mounting a positive film upon supports that are threaded through the apertures at the sides of the film so that certain of the frames of the film are disposed on one side of the supports and the other frames on the other side of said supports, then coloring the frames of said film on one side of said supports and then distinctively coloring the frames of the film on the other side of said supports."

1,775,938. **Color Photography.** ISIDOR KITSEE AND DUFF C. LAW, Sept. 16, 1930. (Class 95-81.5.) *Claim 1:* "The method of coloring the interstitial portion of a celluloid film, one side of which is provided with a developed emulsion in transparent colored figurations in relief and with minute interstices between said figurations extending to the surface of said film, which consists in removing substantially all the air from said interstices and then applying to said side of said film a liquid coloring matter dissolved in a solvent of celluloid in which the material of said emulsion is not soluble, the color of said liquid being complementary to that of said figuration."

1,778,139. **Positive Motion-Picture Film.** ROBERT JOHN, Oct. 14, 1930. (Class 88-19.5.) *Claim 1:* "A motion picture transferring film of the dye transfer type having an image comprising minute color dots in great numbers and more sparsely grouped in the lights and more densely grouped in the shades and being grouped irregularly according to the lights and shades of the original object photographed, and representing a naturally photographic record thereof, said dots and grouping thereof being of such character as to present an apparently unbroken image when projected at above 50 diameters enlargement."

1,778,754. **Optical System** HAROLD N. COX, Oct. 21, 1930. (Class 88-1.) "In apparatus for color photography the combination of a frame, a negative lens element borne by said frame, a plurality of objectives also borne by said frame and to the rear of said negative lens element and symmetrically arranged with respect to the axis thereof, a telescopic lens barrel borne by said frame, and a positive lens element borne by said lens barrel coaxially with the negative lens element aforesaid and arranged in front thereof."

1,780,260. **Method of Producing Pictures in Colors.** GEORGE F. CAPWELL, Nov. 4, 1930. (Class 101-115.) *Claim 1:* "The method of producing pictures in colors, which consists in interposing a protective screen over the surface to receive the picture and beneath a screen stencil, and forcing a color through the stencil and protective screen."

1,781,496. **Apparatus for Color Photography.** HAROLD N. COX, Nov. 11, 1930. (Class 88-1.)

1,782,288. **Projecting Apparatus.** ROHAN CLUFF, Nov. 18, 1930. (Class 88-24.) *Claim 1:* "A projecting apparatus comprising a set of shadow forming elements, a series of light receiving and reflecting elements, one spaced from the other and said elements arranged tandemwise rearwardly of said shadow forming elements, certain of said receiving and reflecting elements having light sources of different colors, means for revolving said elements approximately 1500 revolu-

tions per minute, a telescope arranged adjacent to the inner one of said light receiving and reflecting elements, and a light confining means for said elements and extended upon the telescope at the entrance end of the latter."

1,783,045. **Contact Film Printer.** EDWARD W. KELLOGG, Nov. 25, 1930. (Class 95-75.) A method adapted to allow printing where a plurality of films have different degrees of shrinkage.

1,783,998. **Photographic Reproduction Objective with Two Diaphragms and Its Application as in Printing Positives for Black and White Cinematography, Color Cinematography, or Cinematography in Relief.** HENRI CHRETIEN, Dec. 9, 1930. (Class 88-24.) *Claim 10:* "An apparatus for photographically reproducing cinematographic films including two separate and distinct objectives located side by side and having diaphragms, and optically intermediate convergent optical means adapted to form the image of the diaphragms and a pair of reels on the same identical drive shaft and disposed in front of the objectives, said reels carrying the film to be reproduced and the sensitized film, respectively."

1,784,758. **Cellulose Film.** SAMUEL E. SHEPPARD AND JAMES G. MCNALLY, Dec. 9, 1930. (Class 95-9.) *Claim 1:* "A substantially flat laminated cellulose ester film comprising at least two laminae having the grain of one lamina at an angle to the grain of the adjacent lamina."

1,785,997. **Method of Securing Accurate Color Values in Color Printing and Color Photography.** CARL BLECHER, Dec. 23, 1930. (Class 95-2.) *Claim 1:* "A method for securing accurate color values in color printing and color photography, characterized by the feature that for the colored part images to be placed together intermediate images are made in the respective colors on thin films stretched on frames.'

1,787,023. **Camera and Method of Photography.** JOHN F. SEITZ, Dec. 30, 1930. (Class 88-16.) *Claim 1:* "A combination camera and projector comprising a camera structure having a main lens, a film holder to receive light directly through the lens on the film, an auxiliary lens in the side of the camera, means to reflect light passing through the auxiliary lens on the back of the film, and a lamp holder secured in the side of the camera and shiftable to replace the auxiliary lens in relation to the reflector whereby light may be projected from the holder and reflected through the film and through the main lens."

1,787,201. **Combined Black and White and Colored Image Photography.** WILLIAM V. D. KELLEY, Dec. 30,1930. (Class 95-2.) *Claim 1:* "A transparent carrier coated on one side only with gelatin having a reduced silver image of the minus reds in the original subject and a toned color representation of the red in the original subject."

CLASSIFICATIONS OF PATENTS RELATING TO ART OF COLOR PHOTOG APHY

Class 8—**Bleaching and Dyeing.**

1. Carbon dyes.
5. Dyeing processes.
6. Dyes.

Class 18—**Plastics.**

Processes.

57. Film spreading.

Class 34—**Dryers.**

48. Web.

Class 41—**Ornamentation.**

6. *Painters'* mixing charts.
21. *Surface Type* diaphanous.
42. " " etching.
43. " " resist preparation.

Class 88—**Optics.**

1. Miscellaneous.
16. *Motion Picture Apparatus.*
16.4 " " " color.
18.4 " " " intermittent grip type.
19.5 " " " picture vehicles and elements.
24. *Projecting Apparatus.*

Class 91—**Coating.**

Special Machines

10. Photographic film and plate.

Processes

69. Photographic film and plate.

Class 95—**Photography.**

2. Color.
6. Sensitizing and developing.
7. Sensitizing.
8. Sensitized elements.
9. Films.
75. *Printing* continuous film.
81.5 *Screens* color.
88. Developing.
89. *Fluid Treating Apparatus.*
90.5 " " " roll film.
94. " " " film guides.

Class 101—**Printing.**

Stenciling

115. Multicolor.
127. Stencil plates.
130. *Planographic.*
149. " processes.
150. *Intaglio.*

Multicolor

182. Interrupter.

Printing Members

395. Plates.

Class 154—**Laminated Fabric and Analogous Manufactures.**

40. *Fabric coating and uniting*—processes.

Class 193—**Conveyors—Chutes, Skids, Guides, and Ways.**

2. Chutes.

Class 204—**Electrochemistry.**
Electroysis
9. Chemicals.

Class 242—**Winding and Reeling.**
Reeling and Unreeling
55. Fabrics.
77. Reels.

Class 271—**Sheet or Web Feeding or Delivering.**
Feeding
23. Bottom Feed.

Respectfully submitted,

J. C. BROWN	F. E. IVES
J. G. CAPSTAFF	H. W. MOYSE
W. T. CRESPINEL	W. H. PECK
R. M. EVANS	A. WADDINGHAM

W. V. D. KELLEY, *Chairman*

REPORT OF THE PROJECTION THEORY COMMITTEE*

This Committee was late in getting organized and has, therefore, been able to hold only one meeting for discussion of its program and division of labor among its members.

Because of the fact that this is the first Projection Theory Committee, the boundary lines separating its proper sphere of activity from the subject matter appropriate to several other committees is not definitely established, so that in the choice of material for consideration there is apt to be a certain amount of overlapping of the work of these committees. In so far as reports of facts are concerned, this overlapping would be objectionable only if the various committees did not agree but in so far as concerns matters of opinion, we see no particular objection to a moderate amount of overlapping, and, on the other hand, feel that even some advantage might be derived from it.

In a general way, the work of this Committee deals with the optical and mechanical principles of the mechanism by which a picture is projected on the screen, with the character of the image on the screen, and with its effect on the observer. It does not concern itself with the lay-out or operation of the projection room, with the characteristics of the screen, or with sound reproduction. The range of interests of the Committee can scarcely exclude consideration of

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

the brightness of the projected picture in relation to its effect upon the observer, although our consideration of this subject overlaps some of the proposed activities of the Projection Screens Committee.

Since this Committee is new it seems appropriate to begin with a summary of existing literature. Such a summary should serve as a basis for the future activities of this and succeeding committees, and the work involved in formulating it has been undertaken by a subcommittee headed by Mr. H. P. Gage. In addition to a summary of the literature, the Committee intends to call attention to and to comment on proposed types of projection which may differ from current practice.

Several members of the Society are interested in the development of non-intermittent projectors. Papers dealing with these have from time to time been presented and demonstrations of such projectors have been made before the Society. The Committee feels that these efforts deserve recognition. There is no doubt that the future welfare of the motion picture industry will depend upon the quality of projection as much as upon other factors. The designers of non-intermittent projectors are striving for picture quality superior to anything now obtained with the ordinary intermittent projector. The success of non-theatrical motion pictures depends in a large measure on the cost of equipment and operation, and the designers of non-intermittent projectors are convinced that in the field of the 16 mm. projector this type of projection has promise from the standpoint of economy.

It is claimed that pictures projected with continuously moving film and an uninterrupted light-beam will produce less eye-strain and systemic fatigue than the current intermittent system. The Committee does not feel competent to express an opinion as to the soundness of this claim. Reference will be made later to this point.

In addition to the possibility of improving the quality of the projected picture, it is claimed that non-intermittent projectors provide the following mechanical advantages:

(1) low cost of maintenance;
(2) longer life of film;
(3) silent operation;
(4) advantages in reproducing sound from film;
(5) special adaptability to the reproduction of color by the additive process.

In elaborating items 4 and 5, it may be said that it seems obvious that certain types, at least, of non-intermittent projectors permit higher film speeds than are practical with the intermittent type. While this leads to a greater cost of film, it would help overcome the difficulty of recording high frequencies on 16 mm. film sound track. In color process work it would permit the super-position (due to persistence of vision) of two or more appropriately colored views of each frame from a single print.

The Committee believes that these claims, in general, are sound. However, in making this statement, it wishes to be understood that it is not referring to any particular non-intermittent projector. The Committee has made no study of individual proposals and does not feel that it lies within its legitimate range of activities to do so. It is merely stating that it believes in general that non-intermittent projection systems possess the possibility of realizing the mechanical advantages enumerated above.

The plan of projecting motion pictures from behind the screen has been revived and has received considerable attention during the past year. From the standpoint of the manufacturer of 16 mm. projectors and from the standpoint of economy in the design and operation of small theaters showing 35 mm. film, it has advantages. In the 16 mm. field it makes possible self-contained cabinet model machines; in the theaters it is economical of space.

In order to realize important economy of space in both these applications it is essential that the projection distance be reduced to the least possible value compatible with an image which is satisfactorily sharp and sufficiently bright. This requirement imposes extraordinary demands on the designer of the optical systems involved and, to some extent, on the maker of incandescent lamps. Since the decrease in projection distance, for an image of constant size, can generally be accomplished only at the expense of definition or brightness, or both, the extent to which this decrease may be carried is always a matter of judgment. Incorrect judgment may involve considerable financial loss. If the Society of Motion Picture Engineers could formulate fundamental principles on the basis of which such judgments could be formed it would be rendering the industry very valuable service.

The Committee is impressed with the desirability of increasing the horizontal angle of view in motion picture practice. Two methods of accomplishing this have been proposed of which the most

discussed is that of using the so-called "wide film." The wide-film problem has been studied by the Committee on Standards and Nomenclature so thoroughly that this Committee will give it no further attention. In this statement the expression "wide film" is to be understood to cover all forms of reduction printing from a wide-film negative as well as the proposal that the picture occupy the space of two frames on the film, rotated 90 degrees by the camera and the projector by means of appropriate optical elements.

Another device has been proposed for accomplishing the same result, in which horizontal dimensions are compressed in photographing and expanded by an equal amount in projection by means of anamorphotic systems. Systems of cylinders and of Brewster prisms have been attempted. The optical difficulties of equaling the picture quality obtained by using "wide film" are believed by the Committee to be insurmountable. When analyzed optically, this plan involves lenses whose focal length in the vertical meridian is longer than in the horizontal meridian but whose focal point is the same for both meridians. If satisfactory performance is possible in the horizontal meridian a symmetrical lens is also possible whose focal length is the same as that in the horizontal meridian in the case of both the camera and the projection lens. The use of these comparable short focus symmetrical lenses would, by reason of their greater ease of manufacture and manipulation, result in better definition, but probably in less screen illumination. Assuming that satisfactory designs of the anamorphotic systems were possible, it is a question whether the greater difficulty involved in getting satisfactory illumination with the short focus symmetrical lenses would not be compensated by the very much less difficulty of manufacture and operation.

It remains also to be pointed out that should it be possible to design an anamorphotic lens system for a given object distance it would be optically impossible to maintain the coincidence of focal points for vertical and horizontal meridians for any other object distance. Such a lens system must always theoretically yield an astigmatic image except for the one object distance for which it is designed.

At the meeting of the Committee, considerable discussion developed on the subject of the fatigue involved in viewing motion pictures. It is a matter of more or less common popular belief that more visual fatigue is experienced in viewing a motion picture program than is

experienced in the ordinary employment of the visual function. This opinion has been accepted generally by the motion picture industry. It has been attributed to a variety of causes. The designers of non-intermittent projectors claim that the alternation of light and darkness on the screen, in spite of the fact that it occurs so rapidly that it is imperceptible, is responsible for visual fatigue. Others attribute fatigue to such factors as flicker, insufficient illumination in the projected picture, excessive illumination in the projected picture, contrast with the surrounding field, and poor focusing of the projected picture. Some of the various methods for projecting motion pictures in natural colors are regarded as more fatiguing to view than others.

In so far as we know, very little quantitative work on the fatigue involved in viewing motion pictures has been done, and yet nothing seems more important to the future welfare of the industry than the study of this problem. Excellent and valuable research work is being carried on by private organizations and individuals within the industry but the inherent difficulty of some of the problems involved is so great as to deter such agencies from attacking them and to prevent them from making sufficiently rapid progress. It is a question whether objective methods exist by means of which visual and systemic fatigue developed on viewing motion pictures can be measured. The development of such methods can probably only be accomplished with the coöperation of ophthalmologists, physiologists, psychologists, and physicists.

It is the suggestion of this Committee, therefore, that the Society of Motion Picture Engineers attempt to interest a suitable educational institution to undertake research work along this line. It is further suggested that the University of Rochester is admirably equipped as to personnel to undertake such research at its Institute of Optics, for it has available on its faculties outstanding men in all the categories listed above. In addition, it also is in a position to secure the coöperation of the Eastman Kodak Company and the Bausch & Lomb Optical Company. It is suggested, therefore, that the Society approach the University of Rochester, urging it to take up research work along this line. There is no doubt that the accumulation of data of this sort would be slow, on account of the difficulty of the problem, but the Committee believes that it is the only sound way to establish a basis for a future projection theory.

It is thought probable that the only way in which this work could

be inaugurated would be by the establishment at the University of a fellowship supported by some individual or organization in the motion picture industry. In discussing this with the director of the Institute of Optics, he expressed the belief that the first year's work could hardly be more than exploratory, that is, a study of the possibilities of various methods of attack, with a view to discovering what methods, if any, can be devised for obtaining the desired information. Such a preliminary exploration might be conducted by a graduate student operating under the director of the Institute, who, in turn, would consult with the departments of medicine, physiology, and psychology of the University and with this Committee.

It is by no means certain that it will be possible to find a quantitative expression for the fatigue experienced in viewing a motion picture, assuming that such a phenomenon exists. There is no doubt, however, that great profit would accrue from such information, substituting it for the mass of personal opinion which now exists and which at present serves as the only basis on which to decide questions of projection theory.

F. BENFORD
J. F. LEVENTHAL
W. F. LITTLE
C. TUTTLE
A. J. HOLMAN
H. P. GAGE
H. GRIFFIN
K. F. MOSS (Advisory)

W. B. RAYTON, *Chairman*

PROJECTION PRACTICE COMMITTEE

At a meeting held May 13th in the Paramount Bldg., New York, N. Y., the following resolution was made and passed:

"Whereas, the Standard Release Print has been in widespread use during the past several months and has resulted in the reduction of film mutilation and the elimination of punch-marking of film for change-over purposes, and

"Whereas, the Standard Release Print has contributed to improved change-overs and smoother performances

"Therefore, be it resolved that the Projection Practice Committee go on record as endorsing the said Standard Release Print as a practical step in the improvement of projection."

H. RUBIN, *Chairman*

ABSTRACTS

Wide-Field Pictures on Narrow Gauge Film. Fred Schmid. *Amer. Cinematographer,* **XII,** May, 1931, p. 36. A novel auxiliary lens system, designed by S. H. Newcomer, consists of cylindrical lens elements which are to be used with photographic or projection lenses. The system has a magnification of 1.5 in the horizontal plane only. Its effect is thus to increase by 50 per cent the horizontal angular covering power of any lens with which it is used. This extra field is compressed into the standard aperture width in photography, and magnified to normal proportions when the system is used on the projection lens. Units designed for 16 mm. film are now on the market, made by the C. P. Goerz American Optical Company of New York. They are said to require about 15 per cent more exposure than standard photographic lenses, and to reduce illumination in projection by one-third. A. A. C.

Super-Sensitive Film in Production. Oliver Marsh. *Amer. Cinematographer,* **XII,** May, 1931, p. 11. The advantage of increased speed of the new film is said to be of secondary importance to the improved quality made possible by a better rendition of color and tone values. The results achieved seem to furnish a much closer approach to the natural visual brilliancy of the scene than has been reached with other materials. The author points out that, while less light is needed on the set, reduction must not be made in such a way that the normal balance of the lighting is disturbed. A certain number of light sources are needed for the balanced lighting of any set. A reduction in illumination should be made by using smaller lamps in present equipment; reducing the number of units is liable to spoil the quality of the picture. A. A. C.

Noiseless Test Film Developed by ERPI. T. L. Dowey. *Amer. Cinematographer,* **XII,** May, 1931, p. 27; *Mot. Pict. Projectionist,* **IV,** May, 1931, p. 23. The new test film has no picture, but has two sound tracks which include voice and music selections, several constant-frequency sections from 55 to 8000 cycles, and a length of unmodulated track for ground noise measurement. It may be used to check the general quality of the theater sound reproducing system or to determine the frequency characteristics, and is expected to be a valuable standard for comparison of theater installations. The two tracks are recorded from opposite ends so that rewinding is unnecessary. A. A. C.

The Unsound Sound Business. Henry L. Williams. *Proj. Eng.,* **III,** May, 1931, p. 9. Attention is called to the haphazard merchandising methods of manufacturers of sound equipment, which are claimed to be retarding influences on the growth of the industry. The author recommends that manufacturers sell only to reliable engineers who can help the factory control the use of their product and assume part of the responsibility for satisfactory service. A definite policy of this kind is advised as a necessary basis for prosperity in the industry. A. A. C.

Some Optical Features in Two-Way Television. H. E. Ives. *Bell System*

Tech. J., April, 1931, p. 265. Improvements in the optical systems of both the receiving and sending ends of an experimental two-way television system are explained. The scanning beam of the usual television system is of such intensity that it interferes with the users' vision of the incoming picture. By using a purple scanning beam and blue-sensitive potassium and red-sensitive caesium photoelectric cells, this objection is greatly reduced. In the receiving end the usual Nipkow disk has been replaced by a disk in which each of the spiral holes has an associated condensing lens fixed so as to focus, in combination with a fixed collimating lens, an image of the source on the disk hole. A. H. H.

Condenser Loud Speaker with Flexible Electrodes. P. E. EDELMAN. *Proc. I. R. E.*, Feb., 1931, p. 256. The author describes a condenser loud speaker built of a flexible impregnated cloth carrying a conductive coating and an air-permeable electrode, also flexible. The air space is regulated by means of thread spacers, which also tend to reduce back-lash rustle common to speakers of this type. Several operating circuits using this device either as a reproducer or as a pick-up unit are illustrated. Best results are obtained when these circuits compensate for the response characteristics of the speaker unit. A. H. H.

World's Biggest Cinema. *Kinemat. Weekly (Ideal Kinema Supplement)*, **168**, Feb. 12, 1931, p. 5. Describes the reconstruction work on the Gaumont Palace, Paris, which is one of the world's largest theaters. The ground floor has been lowered to the street level, and the mezzanine and upper balcony, which seat 900 and 1000 persons, respectively, are carried without any visible supporting column. These galleries are supported from each end by a metallic bridge resting on two abutments for which it was necessary to carry the foundations down nearly 100 feet. The total seating capacity of the theater will be 6000. The projection room, covering 900 square feet, will be equipped with six lanterns and six projectors, with plenty of room for future installations. It is estimated that 3000 amperes at 110 volts will be required by the projection room. Power will be furnished by Diesel engines. H. P.

Acoustics in Kinema Design. C. W. GLOVER. *Kinemat. Weekly (Ideal Kinema Supplement)*, **168**, Feb. 12, 1931, pp. 7–11. A certain amount of reverberation is desirable in theaters since it reënforces the direct sound, but excessive reverberation so changes the effective sound wave that speech becomes unintelligible. In the case of reproduced sound a certain amount of reverberation is introduced in the studio recording; moreover, the sound is reproduced at a considerably higher level than the original, and calculations based on the Sabine formula give values too great. Echoes also tend to render the sound unintelligible. In theater design, curves should be avoided as far as possible, although ingenious devices have been used successfully to break up the reflections from curved walls and domes.

Acoustical materials offer difficulties because of their poor fire-resistant properties. If air spaces are used behind the absorbent material, great care should be taken to see that they are completely closed and do not form continuous chimneys. If it is necessary to color the absorbent, stains should be used which will not clog the surface pores as would paint. Dust will also clog the pores so that cleaning of the theater should be extended to the acoustical linings. H. P.

Technicolor Benefits by New Process. F. POPE. *Mot. Pict. Daily*, **29**, May 11, 1931, p. 1. Freedom from the "boiling grain" effect in white areas on

projection of color prints is claimed as a result of an improvement in this subtractive process. Better definition is obtained on long shots than was previously possible. Super-sensitive film has made possible a decrease of lighting necessary for exposing color pictures. G. E. M.

New Fireproof Film Cabinet Demonstrated. *Mot. Pict. Daily*, **29**, Apr. 11, 1931, p. 1. The cabinet is designed to hold eight 2000-foot reels of film presumably in an exchange or a projection booth. It is built to withstand a great deal of heat. Both external and internal fire tests are described indicating the heat insulating properties of the walls. Technical construction details are not given. G. E. M.

New ERPI Photoelectric Cell Cuts System Noise. *Mot. Pict. Daily*, **29**, Apr. 21, 1931, p. 7. Caesium oxide is coated on a half-cylindrical electrode and a small vertical rod forms the anode. The previous cell used potassium as the light-sensitive element. Since the response of the cell is greater, the amplifiers can be operated with reduced gain, thus reducing the volume level of noise within the system. Other improved features are cited. G. E. M.

Testing Sound on Negative. M. F. COOPER. *Kinemat. Weekly Supp.*, **170**, Apr. 16, 1931, p. 25. Describes a method for determining the amount of development which has been given a variable width sound record independently of the exposure given the negative. Photographic requirements which must be satisfied by a good variable width sound negative are: (1) its image density should be about 1.4 and its fog density not more than 0.07; (2) the exposure should have been such that on development to a gamma of 2.0, the image density will be as given under (1). Two ways of giving such a film a known exposure of varying amount are (1) by adjusting the exciter lamp current, and (2) by varying the speed of the recorder. The second is, perhaps, the simplest. The oscillograph is supplied with a weak alternating current of constant frequency, of such value as to modulate the track just perceptibly. The machine is then set in motion, turned off, and allowed to come to rest of its own accord. As the recorder slows down, the exposure increases, and the frequency of the developed wave form is proportional to the exposure. The distance between the peaks of the wave is measured with a scaleometer and the logarithms of the reciprocals of these values are plotted as proportional to the relative exposures. Densities at these points are measured, and when plotted against the relative exposures a value for the gamma is obtained. An example of the method is given. G. E. M.

New Metal Mesh Theater Screen. *Film Daily*, **55**, May 17, 1931, p. 7. It is claimed that very satisfactory results have been obtained using a new type metal mesh theater screen. The features claimed for this screen include: a chemically treated surface free from all gloss, a very high reflection factor, and clear and uniform sound distribution throughout the entire theater. The surface can be washed with hot water and a soft brush without causing injury. The screen is stated to afford a clear view of any picture from any angle of observation, eliminating eye-strain and distortion. The screen surface may be periodically sprayed and for this purpose the company plans to lend, for a period of ten years, a complete spraying outfit with each screen purchased and furnish chemical solutions for resurfacing the screen. C. H. S.

Motion Pictures in the Service of Technical Research. F. DARDIN. *Kino-*

technik, **13,** Feb. 5 and 20, 1931, pp. 40–43 and 65–67. A vertical form of the Ruth boiler for storing steam to equalize power loads in industries was studied by means of motion pictures of a laboratory model of glass. A type of construction preventing undue ebullition of the water and consequent carrying out of water in the steam during discharge of the boiler was arrived at as a result of this study. A mercury arc rectifier was also studied by motion pictures under conditions where direct observation would have been impossible on account of the danger of bursting the glass. The operation of an automatic train-stopping device and the manufacture of "Protos" vacuum cleaners were also filmed. M. W. S.

Correctoscope. *Movie Makers,* **6,** May, 1931, p. 287. This new camera accessory is a combined range finder and exposure meter. It consists of a highly corrected lens, a reflecting prism, and a magnifying eyepiece which is adjustable for any particular eye condition. To find the range, the focusing ring is turned until the magnified image is sharp and the distance is read directly from the scale or, with non-turret cameras equipped with certain lenses, the instrument can be geared to the camera lens so that both operate simultaneously, enabling subjects moving toward or away from the camera to be kept in focus. To determine the correct exposure, a special filter is slipped into place and the diaphragm adjusted until detail in the shadows just disappears. The proper stop is then read directly, requiring no calculations. H. P.

Psychological Acoustics and Sound Films. G. Kögel. *Kinotechnik,* **13,** Feb. 5, 1931, p. 39. In sound film presentations it is disturbing to have the sound come from a direction different from that which would be expected from the action on the screen. If, however, the sound is produced in such a manner that it is impossible to distinguish the actual direction of its source, it will be associated with the proper location on the motion picture screen as a result of certain psychological reactions. This view is upheld by analogy with ventriloquism and the illusion of motion on the screen. M. W. S.

ABSTRACTS OF RECENT U. S. PATENTS

1,796,725. **Focusing Finder.** O. A. Ross. March 17, 1931. An attachment for cameras whereby a motion picture photographer may, if desired, simultaneously photograph, focus, and observe the field being photographed, the delineation of the field or frame in the finder being substantially identical to the delineation of the frame being photographically impressed on the motion picture film at the photographing aperture in the camera. The photographer views a magnified field through a view finder section comprising a finder hood, viewing lens, finder lens bracket, lens mount and lens, and focuses sharply on that field. If the finder lens barrel indicates six feet, not only will the photographing lens be also sharply focused on the same field, but, in addition, the delineation of the field of the photographed field will be substantially the same as the delineation of the field seen on the viewing lens in the finder section.

A photographer may view the desired field or frame through the view finder section and adjust the finder lens barrel for sharpness of image and preferably simultaneously move the camera with respect to the tripod or camera mount until the field or frame seen in the view finder is the desired one, thereafter, or simultaneously, operating the camera to photographically record the scene of the field or frame on the motion picture film. This performance may be accomplished without referring to the distance numerals appearing on the finder barrel.

1,801,268. **Multiple Turntables for Aiding Disk Synchronization.** Frank L. Dyer. April 21, 1931. A plurality of phonograph disk record turntables are provided in independent geared relation to the driving motor. The gearing between one phonograph turntable and the motor provides for normal turntable speed. The gearing between another turntable and the motor provides for a slightly higher speed. A third gearing between another turntable and the motor provides for slightly lower speed. By providing all of the simultaneously operating records, an operator in the projection booth who suddenly finds a condition of non-synchronism existing between the picture and the sound may overcome this condition by at once throwing into position the sound pick-up arms to register with either the faster running sound record or the slower operating sound record, and therefore match the picture and sound without interruption of the program. The multiple arrangement of phonograph turntables also provides means for running a continuous program without interruption and providing a musical program between picture reels.

1,801,450. **Optical Printing System.** F. H. Owens. April 21, 1931. A printer for printing positive film strips from a multiplicity of negative film strips. Provision is made for driving the negative and positive film strips simultaneously by arranging independent sprockets on the same drive shaft. One of the sprockets is adapted to move the strip of positive film. Other sprockets engage strips of negative film. A system of prisms and lenses is provided so that images from different portions of all of the negative strips may be directed upon the positive

strip for integrating upon the positive strip desired views obtained from the negative strips. The driving of all of the sprockets simultaneously from the same drive shaft insures synchronism in the printing process.

1,802,045. **Projector Adaptable for Motion and Still Pictures.** J. BOGOPOLSKY. April 21, 1931. A portable type of projecting machine which may be stopped in any position to project a still picture. The machine comprises a compartment containing a driving motor and a compartment at the front of the projector and above the motor compartment for containing a shutter and an intermittent film-driving means. Two compartments located side by side behind the shutter compartment are arranged to contain a light source and a resistance element. At the moment when the movement of the film ceases an anti-scintillating device becomes effective to filter the light in such manner as to avoid the transmission of heat to the film.

1,802,248. **Automatic Control Circuit for Projection Change-Over.** R. M. GEYER AND CHARLES M. SWEET. April 21, 1931. A control circuit to motion picture projectors for permitting the screening in sequence of film reels without perceptible interruption in the projection between successive reels of film, in which a pair of switches is automatically operated by a solenoid united with a metal plate which cuts off the light beams from the lamp houses when the solenoid is not actively energized, but which is clear of the path of light rays when the core of the solenoid is actuated.

A mechanism is coupled with a plurality of motion picture projectors, in which a movable contact arm controlling the circuit is maintained in a position for keeping open the circuit through one of the units controlling the projectors, and retained in such position by an edge of a film. The motor circuits and the light sources of each of the projecting machines are automatically controlled as the film in one projector nears the end of a reel to produce coöperative functioning of the adjacent projector in bringing about co-extensive operation of the machines without interruption.

1,802,480. **Projection Screen and Sound Reproducers.** H. W. ROGERS. April 28, 1931. Motion picture projection screen which carries a frame structure in the rear for the mounting of a multiplicity of sound reproducers. The sound reproducers may each be adjustably positioned on the frame structure in the rear of the screen and arranged to direct sound through the screen through flared bell structures constituting parts of the sound reproducers.

1,802,570. **Illuminated Stage Setting for Projection Screen.** J. W. OGLETREE. April 28, 1931. Screen for the reproduction of motion pictures wherein a stage setting is provided behind the screen and adjacent the sides thereof for illuminating the space adjacent the screen with light rays contrasting in color with that of the picture, the contrast between the picture and its background serving not only to reduce eye-strain but, by virtue of the blending between the light of the picture and that of the space in which it is situated, functions to create an impression of depth. The screen is mounted within a stage setting for receiving a picture of predetermined color tone. The background is diffused with a subdued colored light, the latter emanating from the back of the screen and being adapted to blend with the color tone of the picture to produce a softening effect between the picture and the immediate vicinity of the screen. Lights are so arranged as to be shielded from the direct vision of the audience and yet

produce that contrasting light effect which will relieve optical strain upon the observers.

1,802,595. **Multiple Sound Tracks for Obtaining Long Records on Normal Length Film.** LEE DEFOREST. Assignor to DeForest Phonofilm Corporation. April 28, 1931. A mechanism for reproducing sound from film where the film has a plurality of longitudinally extending sound records thereon. A light slit is provided in a block which is shiftable laterally of the film. The film is driven past the slit block successively in opposite directions and the slit block moved to align the same successively with each sound record on the film upon each reversal in direction of the film. In this way a sound program of extended length is obtained from a film record of normal length.

1,802,747. **Kerr Cell Employing a Plurality of Elements and Electrostatic Fields.** V. K. ZWORYKIN. Assigned to Westinghouse Electric & Manufacturing Company. April 28, 1931. A Kerr cell comprising a plurality of linear electrodes, interpositioned between the light source and a light-sensitive film. A sound modulating circuit has the output thereof connected to the electrodes of the Kerr cell and controls the operation of the Kerr cell for analyzing polarized light directed through the cell upon a light-sensitive film. The invention consists in subdividing each electrode of a Kerr cell into a plurality of electrode elements, and in so intercalating these elements that the incident light is subjected to a plurality of electrostatic fields during its travel therebetween instead of being subjected to but a single field as in Kerr cells that were known to the prior art. In addition, a linear source of light is so related with the Kerr cell that each portion of the light beam is subjected to a separate electrostatic field.

1,802,530. **Method and Device for Producing Color Films.** OTTO PILNY AND ALEX PILNY. April 28, 1931. Color film which is produced from two series of component color pictures arranged in close proximity on one film projected by means of a single source of light utilizing a mechanical separation of the beams, while avoiding any crossings of the path of the beams, to the front and back of a second film sensitized on both sides so that the two pictures coincide with each other. The first film carries closely adjacent pairs of correlated pictures through which parallel rays are projected, and separately and simultaneously focused to different optical reflecting systems and reflected upon opposite sensitized surfaces of a second film in registering positions of the same height as the pictures on the first film. Both films are then moved step by step the same distance in the same direction for the normal picture height. The second film is thus prepared from the two pictures carried by the first film.

1,802,802. **Gyroscopic Scanning Device for Vertical and Horizontal Scanning.** F. E. BEST. April 28, 1931. Scanning means which includes a high-speed rotary reflector having a relatively great gyroscopic action. The apparatus while in operation can be moved freely in any plane that does not involve a tilting of the axis of rotation of the rapidly rotating part, thereby permitting scanning operations in both vertical and horizontal planes.

1,802,803. **Device for Transmitting Vision Electrically.** F. E. BEST. April 28, 1931. Television system in which two rotatable disks are each provided with a plurality of slots which are adapted to reverse as the disks are rotated to progressively permit the passage of contiguous lines of light. One of the disks is illuminated in proportion to received electromagnetic impulses in close

proximity to the slots therein. The operation of a spark gap is observed through the slots in the disks. The image of an object is projected onto a photoelectric cell in the form of a plurality of contiguous lines of light of varying intensity and each line as it is projected on the cell will vary the conductivity of the cell thereby varying the electric current that will be transmitted through the cell and proportionately varying the strength of illuminating intensity of the spark between the electrodes of the receiving apparatus thereby producing in said receiving apparatus a line corresponding in intensity to the line of light on the cell.

1,803,087. **Safety Device for Regulating Film Loop and Preventing Fire Hazard.** T. T. ALLEN AND J. F. ADAMS. Assignors to Sentry Safety Control Corporation. April 28, 1931. Automatic control for motion picture projectors in which the size of the loop for the feeding of the film is maintained at a predetermined length. Where the film is not uniformly fed under the aperture plate by the sprockets which engage the perforations in the sides of the film, the loop which is maintained above the aperture plate is either greatly lengthened so as to "pile up" or the loop may be diminished until the film is torn or broken. A switch is provided including spring terminals and a cam normally adapted to force the terminals together. A curved plane is fixed on the shaft and extends adjacent on the outside of the loop. There is a finger fixed on the shaft and an actuator extending inside the loop and adapted to engage the finger if the film loop diminishes excessively. The switch is operated to close a circuit for obstructing the light rays and preventing fire hazard with respect to the film until the loop is restored to its normal size.

1,803,088. **Safety Shutter Control and Automatic Change-Over System.** T. T. ALLEN AND HUMBERT GODOY. Assigned to Sentry Safety Control Corporation. April 28, 1931. A shutter mechanism designed to close the aperture to prevent the projection of the film images; first, where it is desired to change the projection from one machine to another; and second, where the projection is faulty, caused by the breaking of the motor belt, the blowing of the motor fuse, the loss of the film loop, or the breaking of the film. The shutter of one projecting machine can be automatically closed and the shutter of an adjacent projecting machine opened under electrical control. In case two or more machines are used, after being properly focused, the first film reel may be mounted in one of the machines and the second film reel in another machine. The mechanism is designed so that by pressing a button, the projection of the first machine will be discontinued and the film of the second or succeeding machine projected simultaneously with the stopping of the first machine so that there will be no appreciable break in the projection. A pair of solenoids is arranged for operating an armature member adjacent to the shutter on each projection machine. A switch is provided for alternately energizing one of the solenoids and de-energizing the other solenoid to raise or lower the shutter.

1,803,133. **Scanning System for Facsimile Transmission.** R. H. RANGER. Assigned to Radio Corporation of America. April 28, 1931. A picture reproducing system for transmitting and receiving picture records, where the picture to be transmitted or received is scanned by moving the scanning system longitudinally of the picture record surface at a plurality of varying speeds. The picture surface is carried upon a cylindrical drum and claws are provided for gripping the picture surface and holding the same securely upon the drum.

The scanning mechanism is operated through a gear shift which controls the rate of movement of the scanner with respect to the picture.

1,803,278. **High-Frequency Control of a Kerr Cell.** T. W. CASE. Assigned to Case Research Laboratory, Inc. April 28, 1931. A sound modulating circuit is provided for operating upon a high-frequency oscillator and producing therefrom high-frequency current modulated in accordance with sound vibrations. The modulated energy is impressed upon a rectifying circuit and from the rectifying circuit the energy is supplied to a Kerr cell. The Kerr cell varies a beam of polarized light in accordance with the modulations impressed upon the carrier current for the production of a photographic record of light waves corresponding to sound waves. The variable light rays thus produced are directed upon a light-sensitive film for the recording of sound in accordance with the initial operation of the sound pick-up circuit.

1,803,313. **Film Guide for Projectors.** CARL BORNMANN. Assigned to Agfa Ansco Corporation. May 5, 1931. A film guide for projectors which consists of a metallic stamping having a rolled, horizontally extending upper edge and resilient fingers depending therefrom and adapted to engage the film adjacent its edges. The resilient fingers bear against the film and maintain the edges of the film flat against the film guide during the movement of the film past the exposure aperture.

1,803,346. **Electromagnetically Operated Light Gate for Recording Sound.** F. H. OWENS. May 5, 1931. A sound record is recorded on a film by an electromagnetic gate which is operated in accordance with the actuation of a sound pick-up circuit for permitting variable light to reach the sensitive film strip. The light gate is operated electromagnetically and admits light through a system of lenses to the light-sensitive film. The parts of the light gate consist of overlapping plates which are shifted vertically with respect to each other for controlling the passage of light upon the film strip.

1,803,403. **Sound-on-Film Attachment for Disk Type Phonographs.** F. H. OWENS. May 5, 1931. An attachment for disk type phonographs in which a frame carrying a pair of reels with a film strip reel thereon is adapted to be mounted within a phonograph cabinet and the reels driven from the phonograph drive shaft. The frame carries a light source and a light-sensitive element between which the film having a sound record thereon is moved. The light-sensitive element operates a sound reproducing circuit in accordance with the sound record on the film.

1,803,404. **Automatic Shutter Mechanism for Controlling Printing Light Intensity.** F. H. OWENS. May 5, 1931. A shutter mechanism is employed in a film printing apparatus, which shutter is controlled in accordance with the intensity of the transmitted light of the printer. As the film is moved past the shutter opening, the size of the shutter opening is varied in accordance with varying light intensities selected for the film. The operating means consists of a continuous band having undulations or cam faces formed thereon. The shutter is mechanically connected to a member which is actuated by the movement of the cam faces on the continuous band to open or close the shutter. The movement of the film controls the operation of the moving band for controlling the effect thereof upon the shutter for determining the light intensity to which the film is subjected.

1,803,572. **Cabinet Assembly for Portable Pictures and Sound Reproducer.** F. VON MADALER. May 5, 1931. A cabinet assembly for a portable motion picture and sound reproducing mechanism wherein a phonograph turntable is positively driven by a shaft and a film reeling device slippingly connected to the drive shaft. A second film reeling device is adapted to be connected to the drive shaft at will. There are film feeding devices disconnectably driven by the drive shaft. The mechanism is mounted within a cabinet having a horizontally extending shelf carrying a reflecting panel which is utilized for the reflection of the reproduced picture on a screen erected above the cabinet structure. The driving mechanism operates a ventilating system to maintain the apparatus within the cabinet cool during the simultaneous projection of pictures and the reproduction of sound from a sound record carried by the film. The apparatus is arranged so that the sound record may be reproduced without the accompaniment of the picture.

1,803,700. **Simultaneous Multiple Scanning and Transmission over Separate Channels.** F. GRAY. Assigned to Bell Telephone Laboratories, Inc. May 5, 1931. Scanning system for television wherein the scanning disk has apertures arranged in the form of a spiral of two convolutions, employed to project two beams of light simultaneously upon the field of view so that the field is scanned by two spots of light moving over different courses. Each of these beams is interrupted or modulated at a distinctive frequency. Light reflected from the field of view may be received upon a single photoelectric cell and the resulting variations impressed upon frequency selective means for separating the components of different constant frequency. The interrupting or modulating of the light beams is accomplished by providing a grating of closely spaced parallel rulings over each of the apertures of the scanning disk, the spacing of the lines being different for one convolution of the spiral than for the other. Separate stationary gratings are provided, one for each convolution of the spiral having, respectively, the same spacing of rulings as the apertures of the corresponding convolution of the spiral. The gratings are so designed as to have rulings varying in opaqueness from the center to the edge to produce variations in the light beam in a sinusoidal manner. A large number of beams may be employed and any suitable means used to direct and modulate the beams. The image currents produced as the result of scanning and comprising a plurality of modulated frequency components are separated by means of filters, demodulated, and transmitted over separate transmission lines, respectively.

1,804,170. **Method of Making Motion Picture Screens.** W. H. C. LASSEN. May 5, 1931. Screen for talking motion picture systems where a laminated screen is provided with perforations uniformly distributed over the surface thereof and through which the sound from loud speakers located behind the screen may be readily directed. The screen consists of a perforated fabric sheet having an adhesive dressing applied over the sheet in a manner to keep the perforations open with a layer of glass globules applied to the dressing extending into the perforations. The glass globules which extend over the surface of the perforated screen provide a reflecting surface for securing finer reproduction of the motion picture.

1,804,268. **Manipulating Attachment for Lens Focusing Mechanism of Projectors.** N. J. NORTHINGTON. May 5, 1931. Lens focusing mechanism

which includes a rack, a pinion, and an upwardly extending pinion shaft projecting through the lens housing. There is a worm wheel secured to the end of the pinion shaft and a manipulator shaft is provided with a worm thereon meshing with the worm on the pinion shaft so that motion may be imparted to the lens focusing mechanism from a position remote therefrom and without interfering with the operation of the motion picture projector.

1,804,289. **Sound Recording and Monitoring System.** L. A. TAYLOR. May 5, 1931. An apparatus for recording sound and at the same time actuating a monitoring circuit for indicating the quality and characteristic of the sound being recorded. The recording circuit includes a galvanometer with a mirror thereof for laterally focusing a beam of light from a light source in accordance with sound waves. The moving beam of light is directed upon a light-sensitive film. An optical system is provided for deriving a portion of the vibrated light beam and directing the said portion of the light beam upon a light-sensitive cell for operating the monitoring circuit.

1,804,295. **Mechanically Resonant Filter for Eliminating 60-Cycle Hum in Reproducing Sound.** DOW O. WHELAN. May 5, 1931. Circuit for eliminating hum of alternating-current supply in the sound reproducer of a sound motion picture system, where the hum arises from the alternating-current light source used to direct the beam of light through the sound record on the film. The incandescent lamp which is used as a light source in a sound motion picture reproducing system is ordinarily energized from the 60-cycle, alternating-current power supply used for lighting the theater. While a frequency of 60 cycles is too high to produce a visually perceptible flicker there is a variation in the reproduced sound due to the low-frequency characteristic of the light source. By this invention a mechanically resonant filter, having an armature tuned for movement in unison with the frequency of the light source, is provided in circuit with the sound reproducing system for eliminating the sound effects produced by the alternating current change in the incandescent light source.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

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CONTRIBUTORS TO THIS ISSUE

Burns, Bruce: Born November 24, 1897, at Dayton, Ohio. B.S. Throop College of Technology, 1919; B.S. in M.E., California Institute of Technology, 1920; research, Trumble Mfg. Co., 1920–21; chief engineer, Pneu-shox, 1922–25; research, Hughes Tool Co., 1925–28; chief engineer, Hughes Development Co., 1928–31; technical director, Multicolor, Ltd., Feb., 1931, to date.

Crabtree, J. I.: See January, 1931, issue of JOURNAL.

Franklin, H. B.: Born April 4, 1889, at New York, N. Y. College of the City of New York; theater department, Paramount Famous Lasky Corporation; president, Fox West Coast Theaters until 1930; president, Hughes-Franklin Theaters, 1930 to date. Author of *Motion Picture Theater Management* and *Sound Motion Pictures.*

Golden, N. D.: Born July 4, 1896, at Bellaire, Ohio. Attended Emerson Institute, Columbia University, Washington College of Law; U. S. Army, 1917–19; assistant chief, Motion Picture Division, U. S. Dept. of Commerce, 1926 to date.

Ives, C. E.: Born February 26, 1902, at Rochester, N. Y. Research Laboratory, Eastman Kodak Company, 1919 to date.

Miller, A. J.: Born March 24, 1903, at Rochester, N. Y. Research Laboratory, Eastman Kodak Company, 1919 to date.

North, C. J.: Born September 13, 1892, at Swampscott, Mass. A.B., Harvard University, 1914; post-graduate work, Columbia University. Assistant, Bureau Branches and Customs, War Trade Board, 1917–18; managing editor, Export Trade and Finance, 1919–23; chief, Motion Picture Division, U. S. Dept. of Commerce, 1929 to date.

Otis, R. M.: Born January 17, 1900, at New Brunswick, N. J. B.S., California Institute of Technology, 1920; Ph.D., California Institute of Technology, 1924; Research Fellow in Physics, California Institute of Technology, 1920–24; engineering department, Western Electric Co., 1924–25; high-voltage vacuum tube research and development, Bell Telephone Laboratories, Inc., 1925–27; director of research, Hughes Development Co., 1927 to date.

Scott, E. K.: Born 1868, at South Leeds, England. Graduated Leeds Univsity. Electrical engineering department, University of Sydney, 1904; lecturer at University College, Finsbury Technical College and Northampton Engineering College; consulting engineer.

ERRATUM

In the June issue of the JOURNAL, p. 807, the biographical sketch of Mr. A. P. Rippenbein was incorrectly presented. The following is the correct version:

Rippenbein, A. P.: Born 1893, at Elizabeth, N. J. Electrolytic metal department, I. G. Farbenindustrie A.-G. 1919–28; general manager, American Rocono, Inc., 1930 to date.

SOCIETY ANNOUNCEMENTS

HOLLYWOOD CONVENTION

The Spring Meeting of the Society was held in Hollywood, Calif., May 25th–29th, with headquarters at the Hotel Roosevelt. The technical program consisted of sixty-five technical papers, including symposiums on color photography, sound recording, studio practices, laboratory practices, and theater practices. In addition to these, there was a symposium of four papers dealing with the camera and the cameraman. The president turned over the chair during the various symposiums to members of the Society who had gained distinction in the particular fields as follows: C. E. K. Mees, Director of the Kodak Research Laboratories, presided over the symposium on color photography; N. H. Slaughter, chief engineer of Warner Brothers Studios, presided over the symposium on sound recording; and V. B. Sease, director of the Redpath Laboratory of the Du Pont Pathé Film Mfg. Company, presided over that on laboratory practices. The final papers program was substantially the same as the preliminary program mailed to the membership two months ago. Inspection trips were made through the Fox and Paramount West Coast Studios, both of which were extremely interesting to the visitors.

The exhibit of motion picture apparatus, held in the gymnasium of the American Legion Auditorium in Hollywood, included an exhibition of apparatus of twenty-four manufacturers, in addition to an exhibit arranged by the Historical Committee of the Society. This exhibit included replicas of old projectors and cameras, in addition to the large collection of clippings of motion picture film illustrating various processes.

On the evening of Monday, May 25th, those attending the Convention were entertained by an exhibition of recent films of interest. Among these were the picture *Tabu*, supplied by courtesy of Paramount Publix Corp., and *Dancing Sinners*, supplied by courtesy of Metro-Goldwyn-Mayer Corp., and a comedy reel by Multicolor.

On the evening of Thursday, May 28th, there was an exhibition of representative films from various studios, showing recent advances in technic.

A picture taken thirty-four years ago by Mr. Oscar B. Depue showing scenes in Europe was projected, in addition to another showing Mr. Depue addressing the Convention, and describing the telegraphone which he used for recording conversations in 1907. A reproduction of the record on the steel wire used in the telegraphone was presented.

Several reels of film were projected through the courtesy of the American Society of Cinematographers showing scenic views photographed on the new supersensitive film. A demonstration was also given of a recording made by the new single ribbon microphone of the choir of three hundred voices in the Mormon Temple at Salt Lake City. Other films were shown for the purpose of demonstrating noiseless recording, re-recording, dubbing, and composite shots made by the Dunning and other processes. The demonstration film by the Fox Studios showed dissolves of various kinds, and one by Tolhurst illustrated results obtained by microscopic photography.

The Society is indebted to Multicolor, Ltd., Technicolor Motion Picture Corp., Fox Film Corp., Columbia Pictures, RKO Radio Pictures, Inc., United Artists Corp., and the Dunning Process Co. for their kind collaboration.

The semi-annual banquet of the Society was held on Wednesday, May 27th, in the Blossom Room of the Hotel Roosevelt, at which more than three hundred persons were present. The opening address was made by President Crabtree, who then turned the meeting over to Mr. Lawrence Grant, Master of Ceremonies. The speakers included Mr. Frank Woods, Dr. C. E. K. Mees, Mr. Lawrence Grant, Dr. Lee de Forest, Mr. Clinton Wunder, Mr. Carey Wilson, Mr. Joseph I. Schnitzer, Mr. Sol Wurtzel, Mr. John Arnold, Mr. Alvin Wyckoff, Mr. Frank Brandow, Mr. William Garity, Mr. Fred Lally, and Mr. Donald Crisp.

A great deal of credit must be given to the Convention Committee, headed by W. C. Kunzmann, and the local Arrangements Committee, headed by Peter Mole, for the large amount of work which they contributed toward making the convention a success. Thanks also are due Mrs. Peter Mole and Mrs. Donald MacKenzie for arranging an attractive program for the ladies attending the convention.

On the evening of May 19th, members of the Board of Governors

were the guests of the Executive Committee of the Technicians' Branch of the Academy at a dinner held at the Hotel Roosevelt, at which time the fullest coöperation between the Society and the Academy was assured. The Society is indebted to the Academy for the assistance of Mr. Clinton Wunder and Mr. Lester Cowan in arranging some of the details of the Convention.

BOARD OF GOVERNORS

At a meeting held in Hollywood at the Hotel Roosevelt, May 24th, the Editor-Manager was instructed to notify Associate members of the Society that a membership certificate may be secured by sending a request to the General Office, accompanied by a remittance of one dollar. This request can be made conveniently by returning the pink slip enclosed in this issue of the JOURNAL, appropriately filled out.

At this meeting, final arrangements for the Convention were completed. These included a reduction in the registration fee from $5 to $2, making the payment obligatory upon all members of the Society. There was some discussion concerning the subscription price of the JOURNAL, the acceptance of advertising for the JOURNAL, and reduction of dues. A motion was made and passed that a committee be appointed "to examine the probable effect on the Society's income of reducing the price of the JOURNAL, reducing the annual membership dues, taking advertising in the JOURNAL, and to report the relative values of advertising, sustaining memberships, and other sources of income for augmenting the Society's funds."

FALL MEETING, 1931

The Board of Governors voted to place the names "New York" and "Detroit" on the post-card ballot to be mailed to the membership shortly for deciding the location of the next convention. The period chosen for this meeting was tentatively set for October 19th to 22nd, inclusive.

JOURNAL AWARD

The motion was made and passed that "an award of $100.00 shall be made annually, at the Fall Convention of the Society, for the most outstanding paper published in the JOURNAL of the Society during the preceding calendar year. An appropriate certificate shall accompany the presentation.

"The Journal Award Committee shall consist of not less than six active members of the Society, to be appointed by the President subject to ratification by the Board of Governors. The Chairman of the Committee shall be named by the President and a two-thirds vote is necessary for election to the award. (Proxies are permitted.)

"The Committee shall be required to make its report to the Board of Governors at least one month prior to the Fall Meeting of the Society, and the award must be ratified by the Board. A list of five papers shall also be recommended for honorable mention by the Committee. These rules, together with the titles and authors' names, shall be published annually in the JOURNAL of the Society."

PROGRESS MEDAL

"The Board of Governors may consider annually the award of a Progress Medal in recognition of any invention, research, or development, which in the opinion of the Progress Award Committee shall have resulted in a significant advance in the development of motion picture technology.

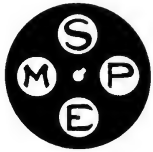
"The Committee shall consist of not less than six active members of the Society, to be appointed by the President subject to ratification by the Board of Governors. Names of persons deemed worthy of the award may be proposed and seconded, in writing, by any two Active members of the Society and shall be considered by the Committee during the month of June; a written statement of accomplishments shall accompany each proposal.

"Notice of the meeting of the Progress Award Committee must appear in the March and April issues of the JOURNAL. All names shall reach the Chairman not later than April 20th.

"A two-thirds vote of the entire Committee shall be required to constitute an award of the Progress Medal. Absent members may vote in writing. The report of the Committee shall be presented to the Board of Governors for ratification at least one month before the Fall Meeting of the Society.

"Recipients of the Progress Medal shall be asked to present their portraits to the Society, and, at the discretion of the Committee, the recipients may be asked to prepare a paper for publication in the JOURNAL of the Society. These regulations, the names of those who have received the medal, the year of each award, and a statement of the reason for the award shall be published annually in the JOURNAL of the Society."

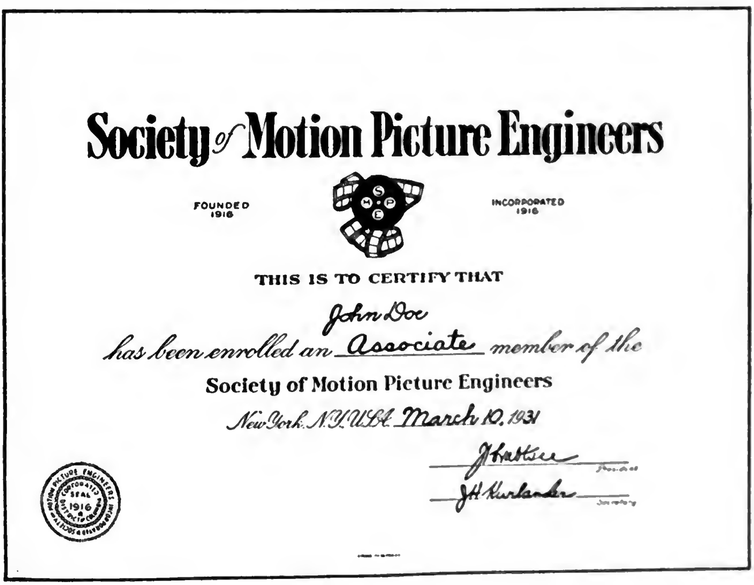
LAPEL BUTTONS



There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of $1.00.

MEMBERSHIP CERTIFICATE

Associate members of the Society may obtain the membership certificate illustrated here by forwarding a request for the same to the General Office of the Society at 33 W. 42nd St., New York, N. Y.,



Society of Motion Picture Engineers

FOUNDED 1916

INCORPORATED 1916

THIS IS TO CERTIFY THAT

John Doe

has been enrolled an Associate member of the

Society of Motion Picture Engineers

New York, N.Y. U.S.A. March 10, 1931

accompanied by a remittance of $1.00. The request may conveniently be made by appropriately filling out the pink slip attached to the contents page of this issue of the JOURNAL.

REPORT OF TREASURER, NOV. 10, 1930, TO MAR. 31, 1931

Cash balance, November 10, 1930		$34,545.04
Receipts:		
Dues	$ 9717.71	
Entrance fees	1205.00	
Journal subscriptions, sales, and reprints	2819.69	
Miscellaneous	91.07	
Net receipts		$13,833.47
Total		$48,378.51
Disbursements:		
Salaries	$ 3786.55	
Committee expenses	2030.26	
General Office Rent	450.00	
General Office Equipment	675.18	
Miscellaneous General Office expenses	464.17	
Publication expenses	6885.73	
Net Disbursements		$15,009.79
		$33,368.72
Cash Balance on hand March 31, 1931		
Savings Account	$26,425.19	
Current Account	6,943.53	
		$33,368.72
Accounts receivable	$ 2373.65	
Accounts payable	1288.45	
	$ 1085.20	1,085.20
Members' equity, March 31, 1931		$34,453.92

Respectfully submitted,
H. T. Cowling, *Treasurer*

SUSTAINING MEMBERS

Agfa Ansco Corporation
Bausch & Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Carrier Engineering Corp.
Case Research Laboratory
DuPont-Pathé Film Manufacturing Corp.
Eastman Kodak Co.
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General Theaters Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Paramount Publix Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

	No.	Price		No.	Price		No.	Price
1917	3	$0.25	1924	18	$2.00	1927	29	$1.25
	4	0.25		19	1.25		30	1.25
1918	7	0.25		20	1.25		31	1.25
1920	10	1.00	1925	21	1.25		32	1.25
	11	1.00		22	1.25	1928	33	2.50
1921	12	1.00		23	1.25		34	2.50
	13	1.00		24	1.25		35	2.50
1922	14	1.00	1926	25	1 25		36	2.50
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1923	16	2.00		27	1.25		38	3.00
	17	2.00		28	1.25			

Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N.Y., and should be accompanied by check or money-order.

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVII **AUGUST, 1931** **Number 2**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

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Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

REVERSING THE FORM AND INCLINATION OF THE MOTION PICTURE THEATER FLOOR FOR IMPROVING VISION*

BEN SCHLANGER**

Summary.—*Two new forms are presented for a motion picture theater, which is considered as a structure intended purely for motion picture exhibition under the best conditions. These forms affect the present floors: one is arrived at by reversing the slope of the orchestra floor, by raising the position of the screen, and by adjusting the seats to the new angle of vision; the other, by changing the horizontal angles of the seats in relation to the screen. The balcony pitch is also reduced, thus economically reducing the height of the structure and affording a more comfortable view of the screen. The plan adapts itself more readily to the enlarged screen than does the present type of theater and allows for improved projection and acoustics.*

It is quite striking that with all the interest displayed during the past fifty years in the theater arts, we have concerned ourselves so little with the theater itself. This statement is made advisedly, fully appreciating the difference in general appearance between what today's theater presents and the theater of fifty years ago, and also giving due cognizance to the plaster turrets and twinkling stars that have become a theater art in themselves during the last decade. Our present theater is the circular stadium of the Greeks plus the balconied enclosure of the Elizabethans, with the proscenium arch as it was added to this structural form. There have been no changes. We are still using this form, even for a theater art so radically different from the stage as the motion picture.

There are, of course, many theaters in which motion picture and stage performances are combined. These combinations came into rather wide usage about fifteen years ago and are still retained, but to a smaller extent than in the period just prior to the introduction of the talking picture.

The theater, as we accepted it with slight change from our predecessors, was little adapted to the exhibition of the silent motion

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Theater Architect, New York, N. Y.

picture. We have come to realize that it is even more poorly suited to the presentation of sound film entertainment. And now the enlarged screen threatens to render the standard theater form obsolete in more points than ever.

Basically, the essential principles of a good theater form are the same for both the stage and screen theater. The difference lies in the degree to which, and the method by which, these principles must be enforced. All theaters should furnish a clear view of the performance, should permit the patron to easily hear and understand the sounds of the performance, and provide for him the proper comfort and safety. Strangely enough, these basic principles, more inexorable than ever in the motion picture theater, have been obscured by those of mere decoration. With all other fields of architecture moving forward, the motion picture theater, weirdly reacting to its modern mechanicalism, has somehow taken on surroundings savoring of oriental voluptuousness.

In the motion picture theater, vision must be more delicately dealt with than ever, because the screen performance is a thing of sheer light. Audibility must be more meticulously cared for, because the sounds of the screen are greatly amplified sounds. Perhaps we need not insist on more comfort for the movie fan than for anyone else, but it may be pointed out that good acoustics and good vision contribute to the patron's comfort as much as do well upholstered seats and ample ventilation.

The theater forms concerned in this paper embrace all three of the principles named. More directly, however, they affect vision. Good vision depends on the disposition of the sight lines, and the physical substance of the motion picture representation requires very special consideration of this disposition, while the problem is even further extended by the enlarged screen.

The sight lines, as now fixed in the present type of theater, cause the spectator to sit with much bodily discomfort and frequently with a distorted view of the screen. On the orchestra floor level, the present arrangement requires (except at the extreme rear of a deep auditorium) that the spectator tilt his head backward to see the upper portions of the screen, the amount of tilt reaching a somewhat painful degree. This is due to the fact that the chairs are placed on a floor that is sloping downward toward the screen, the level of the floor being, in most parts, about even with the bottom of the screen. In the balcony, the steep angle makes it necessary for the patron to

pitch his body forward in order to view a screen that is at a level which is in most cases below that of the greater part of the balcony. Study has shown that it is impossible to correct these faults without entirely disregarding the present theater forms and creating new ones.

In endeavoring to correct the faults of the present type of orchestra seating, the author has developed a plan in which the slope of the orchestra floor is reversed, bringing the high point of the floor nearer the screen instead of the low point as is now the case in the present type of theater. The screen is raised above the level of the eye line of the first row of seats nearest the screen. This plan includes a

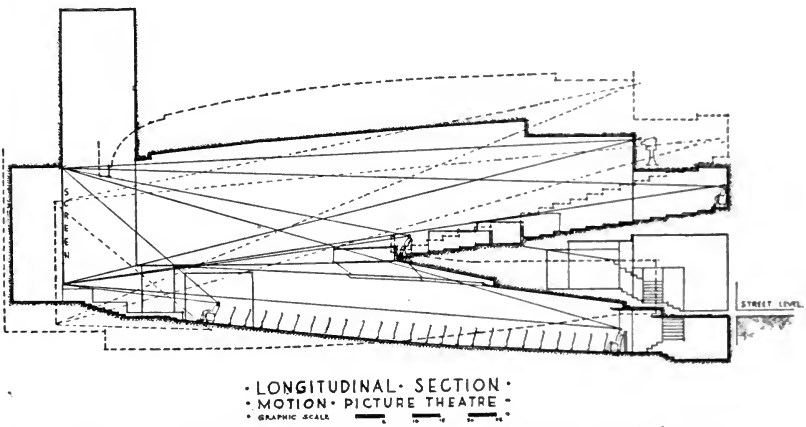
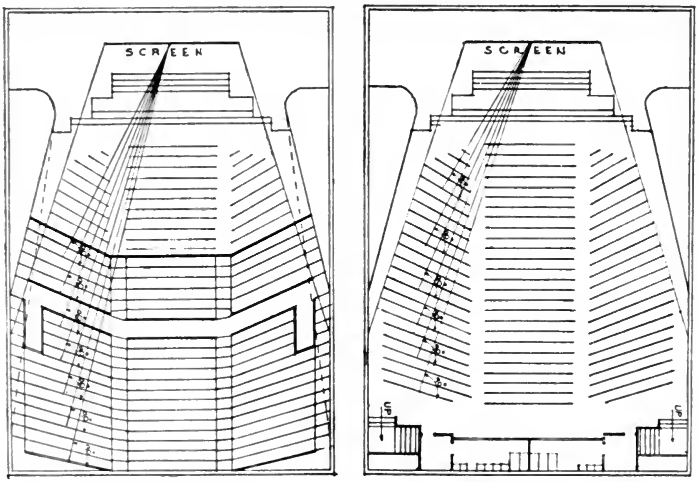


FIG. 1. Longitudinal section of proposed motion picture theater.

systematic tilting of the backs of the chairs on the reversed orchestra floor slope (Fig. 1). By tilting the body backward and permitting the higher part of the floor in front of the seat to support the feet, a natural and comfortable position is assumed which allows the spectator to obtain a complete view of the screen without having to raise his head from its natural position. Seats on the orchestra level more remote from the screen require less tilt. Fig. 3 shows the system of lessening the tilts of the backs of the chairs. The angle of tilt in each case is perpendicular to a line of sight drawn from the eye level to a point on the screen about one-third the height of the screen, measured from the bottom. It is at this height of the screen where most of the action takes place and where the spectator's

eye is chiefly focused. The angle formed between the back of the chair and the seat is 98 degrees and is kept constant for each and every chair. This angle has been found to be most conducive to correct and restful posture. Heretofore, only the placing of the seat and the screen were taken into consideration in determining sight lines, the matter of posture being entirely disregarded. Realizing that variously inclined surfaces are used in theater structures, it seems almost incredible that more consideration was not given to the inclination of the chairs. The reversed slope of the orchestra floor permits establishing a definite relation between the inclination



Upper level. Lower level.

FIG. 2. Plan views of proposed motion picture theater.

of the floor and that of the seat. It would be impossible to apply this system of tilting to the present slope of the orchestra floor because the proper angle of the seat with respect to the back of the chair could not be maintained without leaving the feet unsupported. Sight lines from the orchestra level cannot, therefore, be improved for screen entertainment unless the slope of the orchestra floor is reversed.

While this arrangement distinctly improves the orchestra seating, it also serves as a means by which the complete form of the theater may be revised to suit the requirements of the screen performance. The faults of the present orchestra seating are greatly magnified

when the enlarged screen is used because the spectator then has to tilt his head backward even further than it is now necessary with the small screen. And so the enlarged screen has also served as an important agent in determining a new form for the theater structure.

Reversing the slope of the orchestra floor also brings many decided advantages to the balcony, which can now be kept low and of a slight pitch, made possible by the low point of the rear of the re-

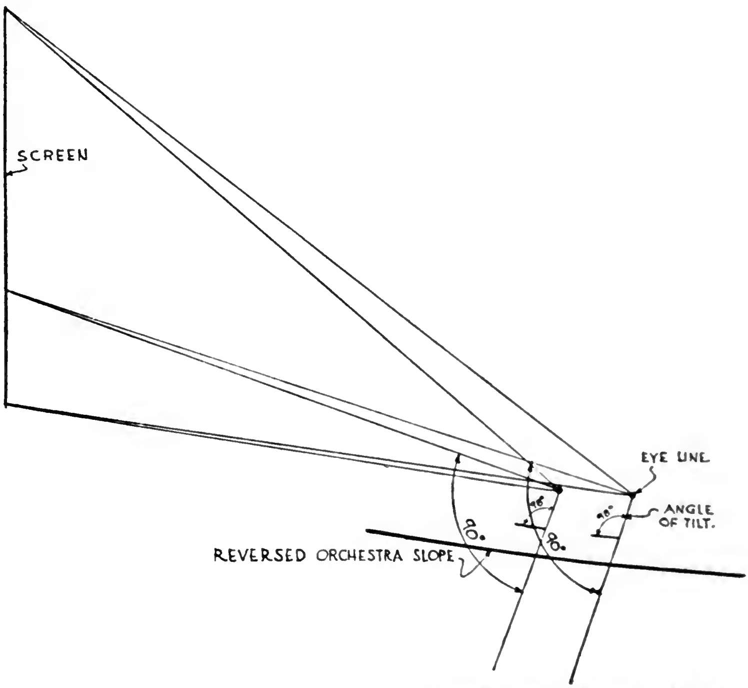


FIG. 3. Diagram demonstrating relation between chair tilt and sight lines.

versed orchestra floor. The balcony thus becomes more desirable for two reasons: (1) due to the fact that the level of the screen is very much the same as that of the balcony the sight lines are greatly improved and, (2) direct and easy access to the balcony from the street level is provided, the difference in levels being surprisingly small. This is made possible by reducing the pitch of the balcony and by placing the rear of the orchestra slightly below the street level (Fig. 1). This plan requires only a few steps and a small easy ramp from the lobby to the orchestra level.

Although the requirements of good acoustics and motion picture projection might have been secondary considerations in this instance, they were by no means disregarded. The shape of the auditorium, as developed from this new disposition of sight lines, lends itself to a better acoustic form and provides for a smaller angle of projection than the shape of the present type of theater. The projector is lowered to a level almost even with the top of the screen.

Besides meeting the requirements of good motion picture exhibition, this form of theater is also economical to build. Fig. 1 shows, by means of dotted lines, the form of the present type of theater compared with the new form, the latter being indicated by the heavy solid outline. Note the reduction in the height of the entire structure, due to the low level of the balcony and the projection booth.

The theater structure shown in Fig. 1 and Fig. 2 has a seating capacity of 1700 seats, the outside dimensions of the structure being 90 feet in width and 140 feet in length. The average interior height is about 36 feet. The screen used for this theater is 22 feet high and 36 feet wide. A theater of these dimensions was selected in this instance for two reasons: firstly, because the dimensions are practically controlled by the requirements for good vision and hearing, and secondly, because its seating capacity would be that of the average motion picture theater. To design a theater for a greater seating capacity it would be advisable to use a somewhat larger screen, increase the distance between the first row of seats and the screen, increase the distance between the screen and the front facia of the balcony, and then to place the additional rows of seats at the rear of the orchestra and balcony, respectively. Of course, there is a limit as to how far back from the screen seats may be placed and yet maintain coördination of vision and hearing. It is also inadvisable to make the width of the theater too great for the angle of vision necessary for the large screen. Fig. 2 shows the maximum angle of vision as 108 degrees in relation to the screen. Seats placed outside this angle would afford a distorted view of the screen. The smaller screen permits a more obtuse angle of vision, which accounts for the fan shape of many existing theaters. A smaller theater than the one shown in Fig. 1 and Fig. 2, using a large screen, could also be designed according to this new plan by reversing the process described for increasing the size.

Fig. 2 shows the seating arrangement of the orchestra and balcony, considering the larger screen. There are here incorporated two

definite changes from the present type of seating. One is the reversal of the front curve used as a guide outline for the seating block. This was necessary because the ends of the curve now in use would cause a certain number of seats to be too close to the screen and too much to one side. The other change consists of eliminating the present system of concentric arcs and introducing in its stead a system of angles in the side banks. The plans in Fig. 2 show sight lines drawn from the center of the screen to about the center of several rows of seats. The backs of the seats are made perpendicular to the sight lines. This allows the spectator to view the complete width of the screen without having to twist his body or lose the support of the back of the chair. In the present seating arrangement the backs of many chairs face in a direction which does not afford the spectator a direct view of the enlarged screen unless he twists his body away from the back of the chair. Even if the present arrangement of concentric arcs were used in a theater employing a large screen the spectators would unconsciously face in the direction suggested by the sight lines in Fig. 2.

It might seem from the nature of this paper, that the problems thus far presented are of a purely practical nature and that some disregard might have been shown for the esthetic and decorative considerations of the interior of the theater. This is not the case—it is necessary to get in behind the turrets, classic columns, and archways to see what really exists. These architectural features have always so bedecked the theater as to obscure that which was functional and expressive of its purpose. Of all the fields of architectural endeavor, what branch could so well express itself as the motion picture theater—an architecture inspired by a mechanism which so delicately transmits various degrees of light and sound? Why not an architecture for the theater interior that would be limited to the treatment of the intensity, placement, and projection of light in its various moods? The very art of the theater should demand more intangible surroundings than those which are obtained by garden walls and other finite unchangeable forms. The larger screen will to a great extent determine the treatment of the interior, its very size making it an integral part of the auditorium.

Generally, the form and treatment of the motion picture theater depends largely on the progress made by the technicians. Ten years ago the presence of a theater architect at a meeting of motion picture engineers would have been unlikely. Today the architect

must come to them to assimilate the many advances which have been made and to incorporate them into his creation of a modern motion picture theater. Never before in the history of the motion picture industry has there been such a need for a common understanding between the technician and the architect. What of all this progress which has been made in the science of motion pictures? Where will the results be utilized? Will it all finally resolve into a little machine in the home in which will be heard and seen pygmy images of people in the midst of dwarfed backgrounds? Or will there be an auditorium that is so motivating and complementary to a large screen presenting a large panorama of figures against backgrounds whose scale in relation to the viewer will be so impressive as to make a home television set a toy?

DISCUSSION

MR. SEAVIER: Mr. Schlanger's paper leads me to believe that at last the projectionist has found a friend, since, as shown in the paper, the balcony, and hence the projection room, will be lowered and the angle of projection will be decreased. Many millions of dollars have been spent in building very fine theaters, but the importance of the angle of projection appears to have been overlooked. The suggestions made are timely and represent a step in the right direction. The projectionist will be enabled to put on a more pleasing show and avoid the distortion so prevalent in present-day theaters. There will be no need for employing the various means for minimizing and compensating for the picture distortion which results from the steep angle of projection.

MR. PALMER: There appears to be a rather ominous factor in this theater design in that the person attending such a theater must necessarily go downstairs for his orchestra seat. If he is required to do this he may gain the impression that his seat is located in the basement and he may be reluctant to pay as much for the orchestra seat as he is willing to pay at the present time. Such a feature may react unfavorably on the box-office receipts.

MR. SCHLANGER: This theater is so designed that there would be no more than two or three steps and a ramp having a slight slope, and one would scarcely be conscious of having to descend to the orchestra seat. It is even possible to place the rear of the orchestra floor at the street level. However, the slight depression of the orchestra is a decided improvement in that it makes the balcony more accessible. Such an arrangement would provide a greater number of good seats than is now available in the present type of theater, and would thus insure greater box-office returns.

MR. FEAR: One of the first things Mr. Schlanger said was that this theater would have a seating capacity of about 1700 seats. That would be a moderately small house, and theaters of that size seldom have balconies. The modern trend of design is toward the stadium type of construction. Furthermore, I believe such a design would be unsatisfactory acoustically. The auditorium of the Mormon Temple at Salt Lake City is probably one of the most perfect acoustical

auditoriums ever built, and acoustical engineers are striving to achieve the same results in the design of other buildings.

At the present time the motion picture industry has a five hundred million dollar bonded indebtedness, primarily upon new theaters. There are very few new theaters being built at the present time, due not only to this huge indebtedness, but due most probably to the fact that there is one seat for every ten persons in the United States, and the normal weekly attendance does not fill the houses to their capacity. In the small theater, with a seating capacity probably under 2500, the motion picture with sound is the primary attraction. In the majority of theaters larger than that, the exhibitors have found it necessary to add stage shows. In the type of theater which Mr. Schlanger has described, it would be practically impossible to have the "flesh show" which has appeared to be necessary in *de luxe* houses. In fact, even second-rate houses have been putting on "flesh shows" in order to stimulate attendance.

I believe that a house of 1700 seats would never require a large screen. We found that when Warner Bros. put in a large size (22 by 40 feet) picture, those sitting in the first ten rows moved back. If this happened in a *de luxe* house the size of Warner Bros.' theater, I cannot see how such large pictures could be shown in a small house.

MR. SCHLANGER: In the design which I suggested, the screen was placed sufficiently far from the first row of seats so that no one would have to move further back from the screen. Due to the large screen, a considerable distance must be provided between the screen and the first row of seats, and economy of ground area must be considered. In order to get the 1700 seats in a minimum ground area it is necessary to add the balcony. Such a number of seats cannot be arranged in the small space provided unless the type of theater suggested is used. A stadium would require a much larger lot.

I would like to hear expressions of opinion from some of the acoustical engineers as to why a form so extremely simple and shaped like a megaphone should not be satisfactory acoustically. The disposition of the sight lines brings down the cost of the building due to the flatter lines, lower balconies, and lower projection booth, all of which tend to decrease the height of the structure and the cubical content, or volume, of the auditorium.

It is true that at the present time stage shows are held in motion picture theaters, and there will probably be a need for them for some time to come, in order to promote box-office receipts. But I hope, and believe, that the talking motion picture will soon be developed to such an extent that there will no longer be a need for "flesh" performances. However, if stage shows are required, an orchestra pit can easily be built into the theater as there is plenty of space between the front row of seats and the screen.

MR. SHEA: I recommend that the Sound Committee investigate the acoustical problems involved. One of the problems which might be considered is the elimination of the pocket under the balcony which appears in so many present theaters.

MR. SCHLANGER: In this theater the ceiling underneath the balcony rises upward toward the screen. In present theaters the front of the balcony is the low point. At all points in the design an attempt was made to shape the surfaces

so they would be acoustically good. The great simplicity of the design will tend to provide good acoustical quality.

The design illustrated in my paper makes it possible to eliminate the fixed proscenium between the audience and the screen. It would be very advantageous to have the form immediately preceding the screen changeable. The setting would not have to be of a structural quality having ornamental plaster and supporting beams. The proscenium could be arranged in such a manner as to give an effect which would best suit the tenor of the picture being shown.

MR. FEAR: The size of the screen is more or less determined by the size of the picture that can be shown without excessive graininess. The distance of the screen from the observer determines whether the grain will be noticeable or not. Primarily the large picture was introduced to improve the view of the screen in large houses, the larger house requiring a larger picture. The more remote a spectator is from the screen the harder it is for him to see the detail on the small screen. In the small house having, say, 1700 seats, no difficulty is encountered in distinguishing all details of a screen 15 by 20 feet having a height to width ratio of 3 to 4. Graininess is a disturbing matter to the audience. The more grain in the picture, the greater is the eye-strain, or the greater the concentration required to follow the picture.

MR. SCHLANGER: There are reasons for enlarging the screen other than that of clarifying the detail of the picture. These reasons might be considered esthetic, dealing with the treatment of pictorial composition and scale, as well as with the problem of widening the action of the picture.

MR. JONES: I would like to congratulate the author of the paper. Of course, it is a radical departure and when anything new is proposed there are always a million reasons given as to why it cannot be done. I believe we have been very fortunate in having a paper as stimulating and imaginative as this and hope that the future will bring something better than we have had in the past. Whether or not the design suggested will be the ultimate practical form does not detract from the value of the paper, which brings to our attention many of the things which can be accomplished. I have expressed myself often to the effect that in the past the theater has been built and the optics of the motion picture put into it. This is a serious attempt to build a theater around the optics of the motion picture, and is something which we will have to think about and analyze.

MR. DIETERICH: I want to express a great gratification in the application of certain well-known optical principles which Mr. Schlanger has shown in his design, especially from the point of view of "easing up" the spectator. The question of looking with ease at the screen includes also the large screen because the ease of looking at something depends on the distance from the object as well as its size. That we have to move back in certain theaters when a wide picture is shown results from the fact that in looking at an object the strain caused by trying to focus the eyes over an angle greater than 30 degrees on each side is very disagreeable and even painful. The first row of seats should be placed in such a position and at such a distance from the screen as to permit a maximum angle of view of 60 degrees. If, therefore, a picture 36 feet wide be shown, we should have for the first row a minimum distance from the screen of about 36 feet. The inclination of the head and body makes it easy to look up at this distance, although a headrest might be considered for such cases. We have about 30 degrees allowable for

easily viewing a picture up and down, and I believe that the structural principles as outlined will help to make it easier to look at the whole screen. This feature should affect the box-office returns to an advantageous extent.

MR. SCHLANGER: I have considered the matter of the head-rest and have found that the vertical axis of gravity of the body thrown backward to view the picture would be so located as to obviate the need for a head-rest, even with the greatest tilt encountered in the seats nearest the screen, and the bodily posture of the viewer would be quite comfortable in viewing the screen from any seat in the house.

STRAIGHT-LINE AND TOE RECORDS WITH THE LIGHT-VALVE*

DONALD MACKENZIE**

Summary.—*A comparison is made of certain types of sound recording by the variable density method, assuming a light-modulation device which is itself free from distortion. These types are: (1) toe recording where only the toe of the H & D curve is used both for negative and for positive; (2) composite straight-line records where negative exposures are confined to the straight-line portion of the H & D curve, and in printing use is made of a portion of the positive toe, the over-all projected gamma being greater than unity; (3) straight-line recording where both negative and positive exposures are confined to their respective straight-line portions, and the over-all projected gamma equals unity.*

The analysis shows that, by observing certain requirements, distortionless sound records can be made on all three types. In signal volume the toe record is louder than the composite and the latter louder than the strict straight-line record. In ground noise the toe record is inferior to each of the other two. The signal-to-noise ratio is greatest for the record where only the straight lines are used and least for the toe record.

The application of noise reduction to these three records is discussed, and it is shown that, with the same freedom from distortion, a noise reduction of 6 db. may be attained in toe recording, 10 db. in the composite type, and 14 db. in the third type.

The fact is emphasized that the pictorial object is not necessarily identical with the acoustic, since pictorially useless toe recording is capable of acoustic excellence.

Sensitometric data are discussed, and it is pointed out that in computing the over-all gamma account must be taken of the ratio of negative printing density to negative visual diffuse density, and of the ratio of projected print density to visual diffuse print density, as well as the distinction between intensity scale and time scale sensitometers.

I. GENERAL REQUIREMENTS

In any discussion of processing technic for sound records on photographic film, it is essential to keep in mind the distinction between the pictorial result desired and the object of sound recording, in order that preconceptions based on pictorial technic shall not be improperly transferred to the technic of sound reproduction.

It is the object of pictorial presentation to reproduce for the eye

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** Electrical Research Products, Inc., New York, N. Y.

a wide range between highlights and shadows, together with acceptable gradations of the intermediate values of the scene photographed. The object of the sound film technic is to produce a positive transparency in which the projected transmission from point to point along the length of the film shall be proportional to the exposure of the negative at the corresponding point. This statement is applicable to the variable width as well as to the variable density track, provided we understand by "transmission" the light reaching the photoelectric cell from a given position of the scanning line on the sound track divided by the light from the scanning line direct. In the present discussion consideration is given exclusively to the variable density type of sound record and to the processing technics which have been proposed.

The requirements of pictorial reproduction have been thoroughly discussed by L. A. Jones,[1] who shows that faithful reproduction of brightness values is attained only when the over-all gamma is unity, with the further restriction that negative exposure and positive printing shall be confined to the straight-line portions of the respective H & D curves. In practice it is common to use an over-all gamma greater than unity and allow the positive print to intrude into the toe of the positive curve, for reasons depending on lens performance and conditions of screen illumination.

The requirement that the over-all gamma shall be unity and the positive and negative exposures shall be confined to the respective straight lines, forms the basis of the classical recommendations for variable density sound records where a light source is available which can give the desired negative exposure. Another processing technic for variable density sound records is based upon a suggestion by F. F. Renwick.[2] This involves toe exposure of the negative, developing the negative to a high gamma and printing it on a positive material similar to the negative material, using the positive toe and developing the print to the same high gamma as the negative. Such a procedure makes it possible to use positive emulsion with sources of restricted intensity and has been recommended even for the unrestricted light source.

Both of these processing methods are in practical use today, and it is the purpose of this paper to investigate the results obtained in the reproduction of sound by the two methods, incidentally establishing the sensitometric foundation more precisely than was possible some years ago.

It will be assumed that we have a light source capable of being modulated by electric currents so that the wave of light variation shall be a distortionless copy of the current wave modulating the light source. For the sake of definiteness in the discussion, we shall limit ourselves to the case where the light intensity is constant and the time of exposure varied by the current, although it will later be pointed out that the conclusions reached apply as well to the case of constant time of exposure and varied light intensity.

The two processing technics to be examined are popularly known as straight-line recording and toe recording, and it will be shown in this paper that excellent sound records can be obtained from each, provided certain requirements are met.

II. SENSITOMETRIC SCALES

In any processing where uniformity of results is desired, sensitometric control of development of both positive and negative is necessary, whatever the type of sound record. The same control is necessary for uniformity of pictorial results, although in this case the trained eye has been used as a measuring instrument with fair success. For the sound record more impersonal measurements are required. Let us examine the sensitometric scales and the kinds of measurements involved.

Sensitometers are classified as time scale or intensity scale. In the time scale sensitometer the sensitometric strip is made by exposing successive areas of the film to successively increasing intervals of time. In the intensity scale sensitometer the successive areas of the strip are exposed for a constant time to increasing intensities of light. This light variation is accomplished by interposing between the light source and the film to be exposed a variable mechanical shutter or a step tablet of varying density.

The sensitometer scales which we take into account in film processing must be carefully distinguished as to the class in which they belong and the kind of light source used in the sensitometer. Furthermore, the kind of density measurements to be made on the developed sensitometer strip must be specified.

We have to distinguish the following types of sensitometric exposure:

(1) The daylight time scale of the Eastman Kodak sensitometer. This instrument uses as a light source the acetylene flame screened to daylight quality, and the sensitometer strip is exposed to a constant light of rather low intensity

for intervals of time which become minutes at the maximum exposure. The exposure times increase in square-root-of-2 steps.

(2) The light-valve time scale of the Western Electric recording machine which exposes the negative to a light intensity of 100,000 meter-candles or more for times varying from 1/20,000 to 1/200,000 second. This recording machine uses a tungsten light source having a color temperature of about 2800°K.

(3) The intensity scale represented by the flashing lamps, where the time of exposure is about 1/20,000 of a second and the light intensity varies up and down from 10,000 or 15,000 meter-candles. The specifications of light quality cannot be stated generally. This scale is not involved in the present discussion.

(4) The intensity scale of the printer, where the light source is usually a 60-watt tungsten lamp and the positive film is exposed through the negative. The time of exposure is about 1/40 second and the intensity of light transmitted by the negative varies from a few score to a few hundred meter-candles.

The relations between the gammas derived from exposures on the above scales involve the failure of the reciprocity law and the dependence of gamma on the color of the exposing light. It is known, for example, that blue light gradations yield a lower gamma than gradations of yellow light and we may expect that, apart from failure of the reciprocity law, the daylight time scale gamma will be lower than the tungsten time scale gamma for the same development. The relation of printer intensity scale gamma to daylight time scale gamma will involve the color difference between tungsten and daylight as well as the difference between time scale and intensity scale exposures and the difference in source intensities.

Experiment has shown that for positive film in a given developer, the H & D curve for a definite gamma has the same shape at the toe, straight line, and shoulder, whether obtained by time scale or intensity scale exposure.* It has also been shown experimentally that for a given development time in the same developer the following ratios exist between the daylight time scale of the Eastman sensitometer and the light-valve time scale of the Western Electric recording machine, and between the Eastman scale and the tungsten intensity scale of the printer:

If the Eastman daylight time scale gamma = 1.00, then

(1) the light-valve tungsten time scale gamma = 1.05
(2) the printer tungsten intensity scale gamma = 0.95
(3) the Cinex (tungsten time scale) gamma = 1.05

These ratios are derived from data collected for the purpose from

* We exclude from consideration sensitometers using extremely low intensities of illumination.

most of the Hollywood laboratories that process variable density sound film. The values in the table apply to a wide range of positive and negative gammas.

The intensity gradations of the printer scale are understood to be gradations of effective printing densities of the negative printed. The significance of this specification will be made clear in what follows.

H & D curves are customarily plotted with visual* densities as ordinates against logarithms of exposure as abscissas. Exposures are given in meter-candle-seconds, and densities are measured visually by the polarization photometer head (or equivalent) with diffuse illumination of the film area being measured. In the Bell & Howell back-shutter printer, the light source sends light to the negative through two apertures in a line, and so the illumination is to some extent specular. Moreover, unless the negative being printed is neutral in spectral transmission, its density as appreciated by the positive emulsion will differ from its visual density by reason of the difference in spectral response of the film and the eye. The ratio of printing density to visual density will depend upon the spectral selectivity of the photographic deposit, and this ratio will combine with the specularity of the printing light to yield a printing coefficient for the negative which includes the color coefficient as ordinarily understood and the geometry of the printing operation. The printing coefficient may be equal to, less than, or greater than unity.**

Filters introduced in printing the sound negative alter the quality of light falling on the negative. This may affect the negative printing coefficient at the same time that the color change affects the gamma to which the positive is developed. The two effects may be opposed: one case was found where they cancelled each other, and the filter served merely to reduce the light as would a neutral gray.

Replacing the 60-watt tungsten lamp by a 200-watt, gas-filled lamp and suitable filter has been tried by one laboratory in Hollywood. The effect was a 12 per cent reduction in over-all gamma in addition to a reduction in exposure.

III. SENSITOMETRIC RESULTS

The accompanying figures will illustrate the foregoing. Fig. 1 is an H & D curve on Eastman positive emulsion, obtained with the Eastman time scale sensitometer, and developed in a sound negative

* "Visual" means in every case "visual diffuse."

** For determination of color coefficient see reference No. 3.

bath to a gamma of 0.50. Visual diffuse densities are plotted against log meter-candle-seconds. The same development would be expected to give a gamma of 0.53 for light-valve exposures, where visual diffuse densities would be plotted against log valve spacings. A slightly shorter development would give a light-valve gamma of 0.50 and, as stated above, the resulting curve would register with the curve of Fig. 1.

Values of printing coefficient ranging from 1.0 to 1.4 have been found. The printing coefficient is the ratio of gradations of effective printing densities to gradations of visual diffuse densities of the negative. Admitting the possibility of reflections from the negative in

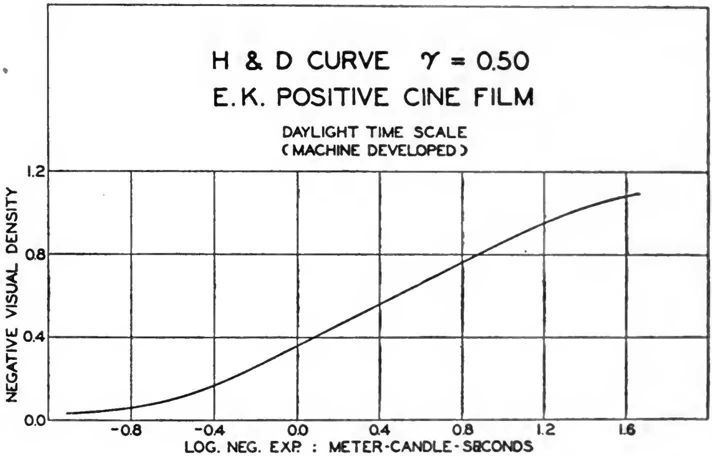

FIG. 1. Sound negative development.

the printer which differ from those occurring in the visual diffuse densitometer, we can write:

$$\text{Effective printing density} = A + (\text{visual density} \times P.C.)$$

The effect of the constant A is a shift parallel to the density axis without change of shape, and thus is equivalent to a change in light intensity in the printer lamp. The $P.C.$ for the sound negative bath which produced Fig. 1 was 1.2; the effecting printing gamma then was 0.60.

Fig. 2 exhibits the H & D curve of gamma 2.0; it is an Eastman time scale strip developed at the Fox Laboratory in Hollywood in the positive bath which serves for the sound negative and for the Movie-

tone print. The printing coefficient of the negative was found to be 1.2. The method of determining *P.C.* is described in connection with the next figure.

Fig. 3 is a plot of print visual density *vs.* negative visual density in the Fox processing. A negative sensitometer strip, the visual densities of which were carefully measured, was spliced into a loop of clear film and printed at printer points 3, 6, 9, 12, 15, and 18. Prints made with the 60-watt lamp with no filter at points 6, 12, and 18 are represented in Fig. 3. Similar prints obtained with No. 39 filter and a ground glass gave curves of the same shape. The net effect of the filter and ground glass is to reduce the light; the change in printing

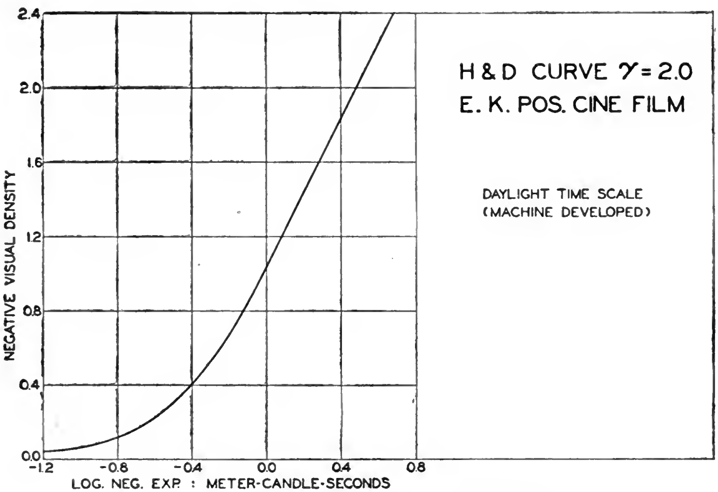

FIG. 2. Composite print development.

coefficient due to the filter is offset by the reduction in print gamma due to the change in light quality.

Unless there is a variation in gamma with printer point, the shift of printer point is equivalent merely to shifting the range of negative densities to cover successive (and overlapping) portions of the whole printer curve. To obtain Fig. 3, the print visual density was plotted against the negative visual density for each printer point separately, and the plots were brought into register by appropriate shifting along the axis of negative visual density. Fig. 3 gives no indication of a variation in gamma with printer point; this result has been confirmed on every printer so far examined, provided accurate

density measurements are made on the negative loop and on the positive prints.

Study of Fig. 3 shows that a change of 3 printer points is equivalent to a shift of 0.10 along the axis of negative visual density. This is confirmed by all the prints made of this negative: the print at point 6 registers with that at point 18 when shifted 0.40 in visual density. It is known from illumination measurements at the printing gate of the Bell & Howell back-shutter printer that between points 3 and 18 there is a linear logarithmic relation between printer point and meter-candles at the gate; a change of 12 printer points means a change of 0.48 in log meter-candles. A change in visual density of 0.40, therefore, is equivalent to a change of 0.48 in log effective exposure; the printing coefficient of this negative then is 1.2.

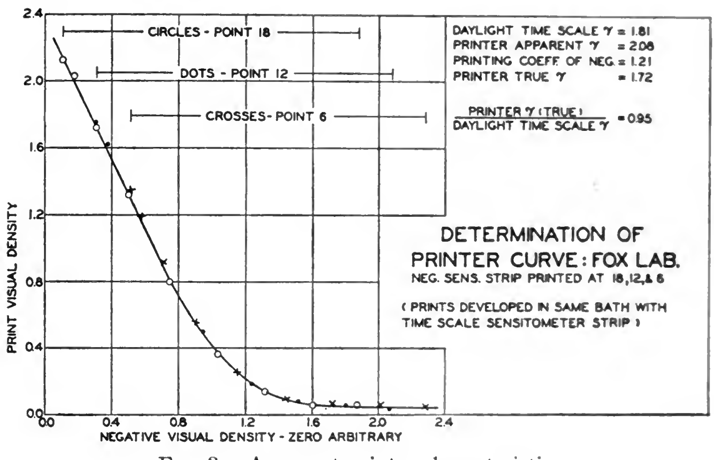

FIG. 3. Apparent printer characteristic.

While this determination lacks precision both in the illumination measurements and in the registrations of the different print curves, it checks closely with the relation previously stated between the daylight time scale gamma and the printer intensity scale gamma. It will be recognized that a curve plotted between print visual density and negative visual density will give an apparent printer gamma higher than the true, if the *P. C.* of the negative is greater than unity. The gradations of negative density should be multiplied by the negative *P. C.* to obtain the true gradations of effective exposure on the

positive material. When this is done the true printer gamma is seen to be less than the apparent in the ratio of the *P. C.*

If the daylight time scale gamma is γ_T, then the true printer

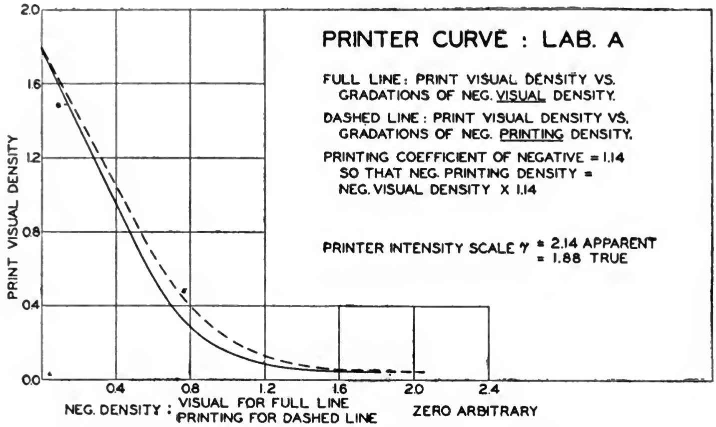

FIG. 4. Negative printing coefficient = 1.14.

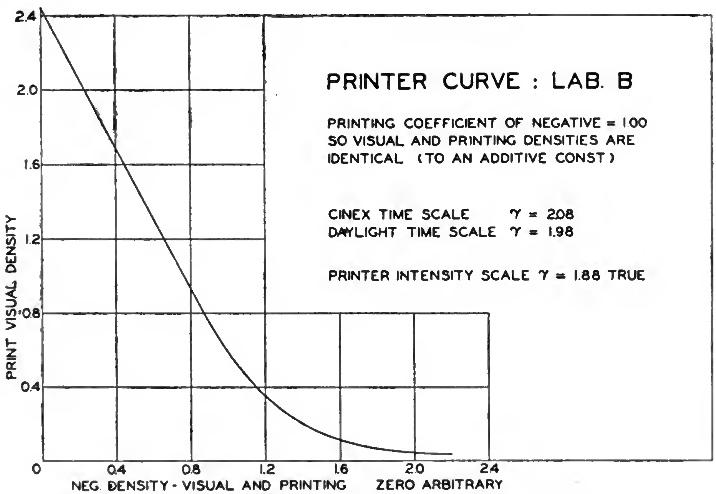

FIG. 5. Negative printing coefficient = 1.00.

gamma is $0.95\gamma_T$, and the apparent printer gamma (print visual density *vs.* negative visual density) is $0.95\gamma_T \times$ neg. *P. C.* From the data shown in Fig. 3, the *P. C.* is 1.21.

The relation just stated between printer intensity scale and Eastman time scale gammas serves to reconcile the results of printer studies at five laboratories in Hollywood. These laboratories use different formulas for the sound negative developer. Four of them use the Bell & Howell back-shutter printer with no modification of printing apertures. The negative printing coefficients thus differ from one laboratory to another, and curves from two of these laboratories (referred to as "A" and "B") are shown in Fig. 4 and Fig. 5.

Fig. 4 is a curve obtained in the same way as Fig. 3 by consolidating the individual curves at separate printer points. The sound negative printed in this series of measurements had a printing coefficient of 1.14. The curve of Fig. 5 is similarly obtained from studies in laboratory "B," where the sound negative had a faint magenta color and its printing coefficient was 1.0. This value is indicated both by the registrations of separate print curves and by taking into account the ratio 0.90 between the Cinex time scale gamma and the printer intensity scale gamma.

The positive formula at laboratory "A" was at this time the same as at laboratory "B" except that a small amount of citric acid was present in one of them. Since the printers are the same, and the positive prints were developed in the same type of developer to the same contrast as read by the sensitometers (taking into account the ratio of the sensitometer scales at the two laboratories) we should expect that the true printer curves, each corrected for negative printing coefficient, would be identical in shape and would register on each other. The shift along the axis of negative printing density required to effect this registration is due to the difference between the arbitrary zeros of Fig. 4 and Fig. 5. The agreement between the two curves when so treated is shown in Fig. 6. Here one set of points is the curve of Fig. 5, requiring no correction for printing coefficient. The other set is taken from the curve of Fig. 4, the corresponding negative visual gradations having been multiplied by 1.14, the negative printing coefficient at laboratory "A."

We may then take the curve of Fig. 6 to be the true printer curve for this positive formula and for the standard printer when the Cinex time scale gamma is 2.08. The ordinates of the curve are print visual densities. The abscissas are negative printing gradations. Therefore, if it is desired to construct the apparent printer curve in this developer at this time of development for any other negative printing coefficient than unity, the abscissas of Fig. 6 need only be divided by

the negative printing coefficient under consideration. The development to a positive contrast of 2.08 by Cinex or 1.98 by daylight time scale is one which is commonly used for picture prints and, therefore, also for the sound print of the composite film.* It will be noticed that this value of daylight time scale gamma differs by only 1 per cent from the Fox positive processing represented in Fig. 2. Errors no greater than 1 per cent can scarcely be avoided and it is safe to say that the curves of Figs. 2, 4, and 5 belong to the same developed contrast. Besides this, the shapes of the toes of the three curves,

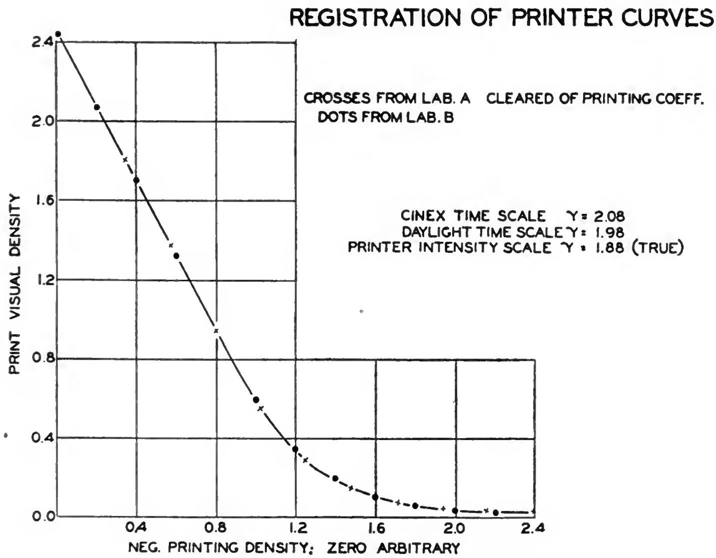

FIG. 6. True printer characteristic.

when printing coefficients are eliminated, are found to be substantially identical.

A common value of the negative printing coefficient is 1.2. Equally common is the positive contrast of 2.0 by the daylight time scale. Having now the true printer curve for this daylight time scale positive gamma, we can construct an apparent printer curve between print visual densities and negative visual densities which will be representative of the processing of Fig. 2, and of the results at laboratories "A" and "B" of printing a negative whose printing coefficient is 1.2.

* In Hollywood studios there is a recent tendency to lower print gammas.

IV. THE PROJECTION FACTOR

At this point it is appropriate to introduce the relation between projected print density in the reproducing sound head and visual print density measured on the densitometer. Data relating projected and visual densities of various samples have been collected at numerous times, and it has been usually found that the ratio of projected to visual density is not a constant but increases at the lower values of density.

This matter is discussed by Tuttle and McFarlane,[4] who tabulate values of visual diffuse density and of reproducer density for positive film. In their work the reproducer density was measured by a galvanometer in series with the potassium cell. Similar measurements of densities were made at the Fox laboratories in the course of the present work. In Fig. 7 are shown plots of the data obtained in these measurements and of the data tabulated by Tuttle and McFarlane. It will be observed that to the points in both plots straight lines of the same slope can be fitted, intersecting the axis of projected density at a point to the right of the origin. The data are represented by the equation:

$$\text{Projected print density} = K + (1.22 \times \text{visual print density})$$

where K has the values 0.03 and 0.04, respectively, for the Fox data and for the Tuttle and McFarlane data.

The existence of this constant K may be attributed to reflection of light at the burnished surface of the print. Similar measurements on specimen photographic densities not burnished show a straight line passing nearly through the origin, the value of K being 0.01 and the slope 1.25. These specimens were obtained from the Eastman Kodak Company in Rochester and were developed according to their own formula.

The reflection of light from the emulsion surface in the sound head is undoubtedly different from the reflection in the visual densitometer where the emulsion lies just above a diffusing surface. The plots of Fig. 7 indicate reflections of 7 and 9 per cent, respectively, if the constant K is identified with this effect.

The existence of an additive constant in projected density implies merely a displacement along the axis of projected print density and involves no change in shape of the curve. This additive constant becomes a multiplying constant when projected transmissions are taken instead of projected densities and so is equivalent to a slight

reduction in the light from the reproducing lamp. It is, therefore, justifiable to multiply print visual densities by a constant to obtain projected print densities. This constant, hereinafter called the "projection factor," involves the specularity of the reproducing illumination and the difference in spectral response between the photoelectric cell and the eye. The projection factor thus is allied to the negative printing coefficient.

It is known that projected densities for the potassium cell are somewhat lower than for the caesium cell. In a particular case investi-

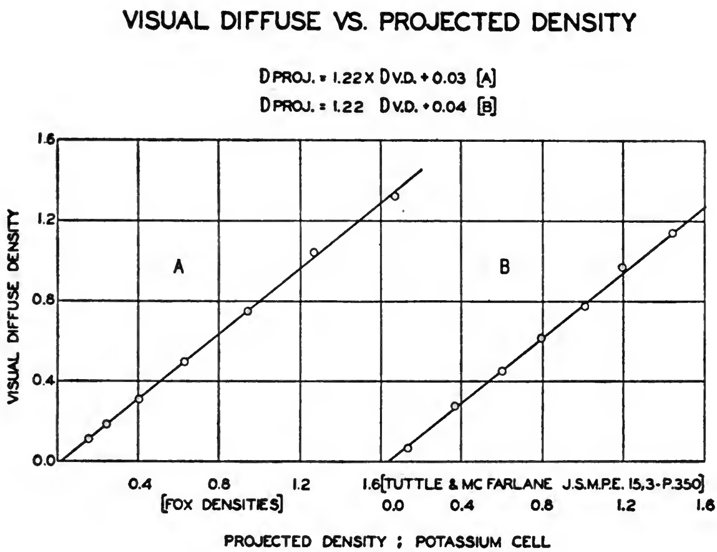

FIG. 7. Projection factors.

gated some time ago, the reproducer densities using the Western Electric potassium cell were 6 per cent less than when using the Western Electric caesium cell. A convenient compromise, nearly correct for both potassium and caesium cells, is obtained by taking 1.25 as the ratio of projected to visual gamma. On this basis it is possible to construct a curve based on Fig. 6, multiplying the print visual densities by 1.25 and dividing the negative printing densities by 1.2. The resulting curve is the projection characteristic of prints from a negative having a printing coefficient equal to 1.2, the print development being carried to a daylight time scale gamma of 2.0.

V. CHARACTERISTICS OF TOE RECORDING

In Fig. 8 a graphical construction adapted to the use of the data which have been presented shows the photographic characteristic of toe recording. In the lower right-hand quadrant of this figure is replotted the curve of Fig. 2. In the upper left-hand quadrant is plotted from Fig. 6 the curve of projected print densities *vs.* gradations of visual negative density, using the projection factor 1.25 and

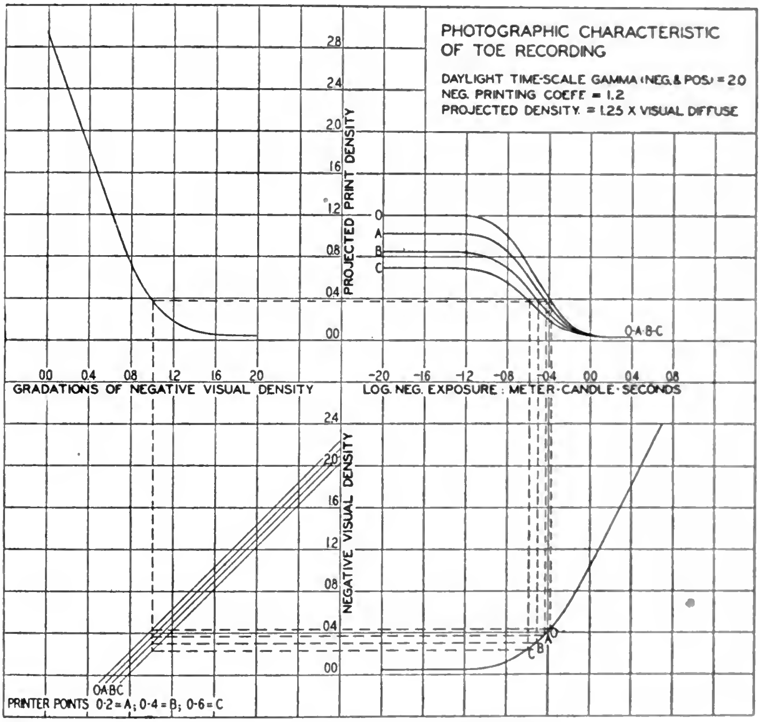

FIG. 8. Toe recording construction.

the printing coefficient 1.2. Choosing any point on the negative H & D curve and the projected print density to which this point shall be printed, we determine the construction by drawing a horizontal line through the chosen negative density in the two lower quadrants and a vertical line in the upper and lower left-hand quadrants through the print curve at the chosen projected print density. Through the intersection of these lines in the lower left-hand quadrant a straight line at 45 degrees is drawn to represent the printer point. A vertical

line through the chosen point on the negative curve intersects a horizontal line through the chosen positive projected density and locates a point of the over-all curve in the upper right-hand quadrant.

The oblique line in the lower left-hand quadrant serves to transfer the negative densities to the scale of negative visual gradations on the horizontal axis at the left. The location of this line determines the portion of the positive projected density curve which shall be covered by the range of negative densities of the sound record. Remembering that the printing coefficient of the negative is 1.2 and that a difference in negative visual density of 0.10 is equivalent to a change of 3 printer points, we can locate 45 degree lines in the lower left-hand quadrant corresponding to any desired number of printer points above or below the line we start with. For the sake of illustration, four such printer point lines are drawn in Fig. 8 at intervals of 2 printer points. The dashed horizontal lines in the two lower quadrants determine the negative exposures which will be printed to the same projected print density by the appropriate printer lines. For each printer point the rest of the construction follows immediately giving the over-all photographic characteristics O, A, B, and C of the upper right-hand quadrant.

The printer curve of the upper left-hand quadrant is reversed left and right from the usual plotting of such data in order to show more clearly the effect of the positive toe. All four of the over-all curves terminate to the left in horizontal lines which show the effect of printing the negative fog density, and on the right they terminate in a horizontal line, the same for all four curves because of the positive fog. Photographically considered, these curves are by no means suited for pictorial reproduction in as much as the range between highlights and shadows is limited and the range of negative exposures which show gradation in the final print is narrow. The processing represented by Fig. 8, therefore, gives a poor picture. How well it serves for sound reproduction cannot be clearly seen from this plot, and we require a plot of projected print transmission *vs.* negative exposure.

In Fig. 9 the four over-all curves of Fig. 8 are replotted in arithmetical terms. It will be seen that in each of the four curves of Fig. 9 there is a region where the curve is nearly straight. Heavy dots indicate the limits of approximately linear reproduction and the proper average transmission. It must be recognized that the curve is nowhere ideally straight but is S-shaped, with a point of inflection,

on each side of which the departure from a straight line is small enough to be ignored within a certain range of negative exposure. The object of sound-record processing is to select a negative exposure and a printer point such that the departure from linearity shall be small and symmetrical on both sides of the exposure selected, whenever strict linearity is not attainable.

Printer point C (Fig. 9) clearly shows an approximately straight portion much shorter than printer points O, A, and B. The straight-line portions for O, A, and B are of approximately the same length, the centers being at nearly the same projected print transmission, but

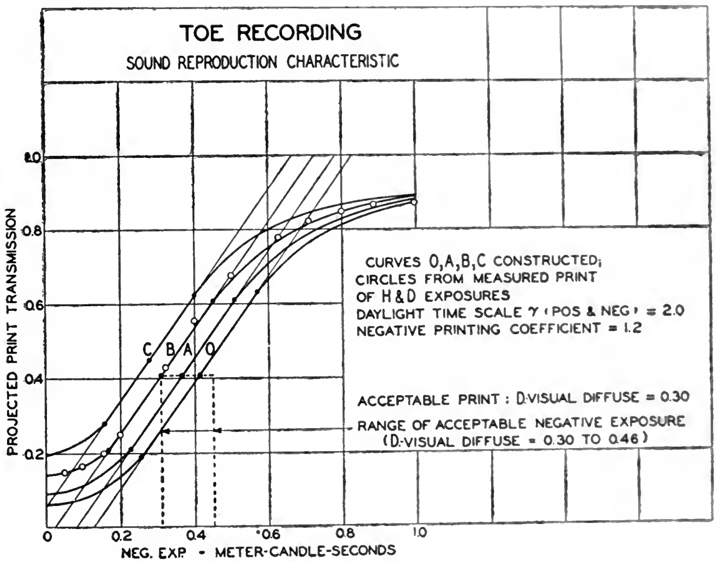

FIG. 9. Toe record positive.

corresponding to different values of unmodulated negative exposure. A print at 2 printer points above O would no doubt be equally successful, but a print 2 points darker still would undoubtedly show limitations as great as those of C.

The curves definitely suggest that equally good results are to be expected from unmodulated negative exposures between 0.30 and 0.45 meter-candle-seconds, provided the printer points are so chosen that the projected positive transmission shall be the same for all these negatives—namely, about 42 per cent, corresponding to a visual print density of 0.30, visual transmission 50 per cent. For negative ex-

posures within these limits of permissible variation the modulation of the sound record should be restricted to 40 or 50 per cent, in order that the maximum and minimum negative exposures shall not sensibly encroach on the definitely curved upper and lower ends of the over-all curves. Within this range in the choice of negative unmodulated exposure, restricting the modulation as indicated, and choosing the printer point for a projected positive transmission of 42 per cent, we obtain prints of substantially equal volume. The amplitude of photoelectric cell current is determined by the swing in transmission corresponding to the swing in negative exposure, and it is seen that in curves *O*, *A*, and *B* the swing in transmission is about 44 per cent.

The proponents of toe recording for sound records have usually advocated a negative visual transmission of 50 per cent, printed to a positive visual transmission of 50 per cent, with negative and positive gammas as in Fig. 8. It appears from the preceding discussion that the unmodulated negative transmission is not limited to this value although the appropriate printer point yields the same positive transmission for each negative unmodulated exposure within the permissible range.

Based on the above conclusions, a toe record on Eastman positive film was made with the light-valve, setting the recording lamp to result in an unmodulated track density of 0.30 visual diffuse when the negative is developed to a daylight time scale gamma of 2.0.* Following the usual recommendations for toe records this was printed to a positive track density of 0.30 visual diffuse, the print being developed as had been the negative. These requirements were exactly met at the Fox Laboratory.

A daylight time scale exposure on the negative was printed through on the positive. The printed-through densities were measured and converted to projected densities by the projection factor, 1.25. This over-all curve in terms of projected print density *vs.* log negative exposure in meter-candle-seconds was translated into projected print transmissions *vs.* negative exposures and the open circles in Fig. 9 show how closely the actual result agreed with the expected. Perfect agreement would locate the circles on the curve in Fig. 9 at printer point *B*. This check appears satisfactorily to vindicate the construction employed and the considerations on which it is founded. The record showed excellent quality for both speech and music.

* The light-valve gamma would be a little higher than the daylight gamma, but the shapes of the toes would not differ appreciably.

Limitations of toe recording remain to be discussed, but the emphasis at this point is upon the fact that, by properly choosing the negative exposure, negative modulation, and printer point, a processing which is pictorially useless gives a result which is acoustically excellent.

A claim made for toe recording is that the sound negative, when projected, is of as good quality as the print to be made from it. In Fig. 10 the negative curve in the lower right-hand quadrant of Fig. 8 is replotted (taking account of the projection factor) in terms of pro-

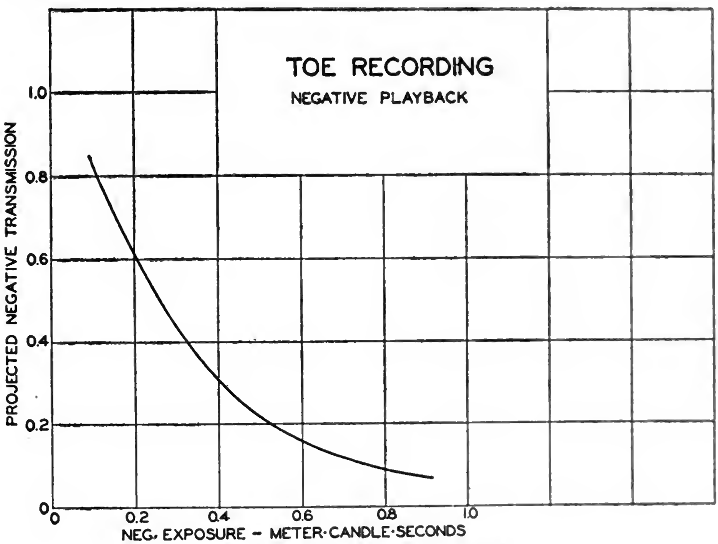

FIG. 10. Toe record negative.

jected negative transmission *vs.* negative exposure. No part of this curve is straight.

The foregoing discussion of toe recording has made use of H & D curves derived from time scale exposures, whereas the flashing-lamp records give intensity scale variations of exposure on the negative. In the region of the negative characteristic to which the toe exposures are confined, the difference in shape for the same development between intensity scale and time scale exposures is so small as to be negligible and the conclusions stated above apply substantially to either type of negative modulation.*

* In the Fox development, daylight time scale strips at gammas of 1.81 and 2.15 show toes which do not differ in shape below a visual density of 0.80. It is

VI. CHARACTERISTICS OF STRAIGHT-LINE RECORDING

Before studies were made of the negative printing coefficient, projection factor, and relations between sensitometric scales, the curves of Fig. 1 and Fig. 2, where the negative gamma is 0.50 and the positive 2.0, would have appeared to define a sound record processing in conformity with the classical specification of an over-all gamma of unity. As a matter of fact, such processing can be used successfully for the reason that the positive development represented by Fig. 2 is suitable for the picture prints, and a development corresponding to Fig. 1 can be readily provided for the sound negative on positive emulsion.

Taking into account the projection factor, the negative printing coefficient, and the relation of true printer gamma to sensitometer gamma, we can enumerate the factors which enter into the determination of the over-all projected gamma. They are as follows:

(1) the light-valve gamma, derived from the curve plotted between negative visual density and log light-valve spacing;
(2) the apparent printer gamma, derived from a plot of print visual density *vs.* negative visual density;
(3) the projection factor, depending somewhat on the type of cell and the structure of the sound head. This factor has been taken as 1.25 for reasons given above.

The over-all gamma is the product of the light-valve gamma times the apparent print gamma times the projection factor. It is this triple product which should be unity in order strictly to conform to classical requirements. The apparent printer gamma must be determined by making prints of the actual negatives for which the light-valve gamma is derived. The three factors whose product is formed may be written thus:

$$\overset{(1)}{\frac{\text{visual negative density}}{\text{log valve spacing}}} \times \overset{(2)}{\frac{\text{print visual density}}{\text{negative visual density}}} \times$$

$$\overset{(3)}{\frac{\text{print projected density}}{\text{print visual density}}} = \frac{\text{print projected density}}{\text{log valve spacing}} = \text{over-all gamma}$$

It is customary to control the processing by the use of suitable sensitometer exposures developed along with sound negatives and

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not likely that the flashing-lamp gammas would differ more than 10 per cent from the daylight time scale gamma, and it has been mentioned that an intensity scale curve coincides with a daylight time scale curve of the same gamma. There remains the chance that a different negative exposure would be required to give the desired negative density.

sound prints. If, for example, the daylight time scale sensitometer is used to expose the sensitometer strips, we have the following relations between sensitometer gammas and the factors listed above:

(1) Light-valve gamma = 1.05 × daylight time scale negative gamma
(2) Apparent printer gamma = 0.95 × daylight time scale positive gamma × negative printing coefficient
= true printer gamma × *P.C.*
(3) Projection factor = 1.25

If a Cinex tungsten time scale sensitometer is used to make the control strips, it should be remembered that the Cinex gamma is 5 per cent greater than the daylight time scale gamma and 10 per cent greater than the true printer gamma. Concisely stated, the over-all gamma equals 1.25 × product of positive and negative daylight time scale gammas × negative printing coefficient, or 1.12 × product of Cinex negative and positive gammas and negative printing coefficient.

The sound negative bath which gave a daylight time scale gamma of 0.50, the curve of Fig. 1, would have given this same curve for Cinex exposures had the development of the Cinex strips been a little shorter. The equality of Cinex gammas and light-valve gammas permits us to use the curve of Fig. 1 as representing the light-valve gamma of 0.50. The bath from which the curve of Fig. 1 was obtained produced sound negatives with a printing coefficient of 1.2. The curve of projected print density *vs.* negative visual density, shown in the upper left-hand quadrant of Fig. 8, describes sound positive processing to a Cinex gamma of 2.08, of prints made from a negative of printing coefficient 1.2. From what has been said just above, the over-all projected gamma, instead of being unity, is 1.4.

It has been the practice to set the recording lamp to obtain an exposure on the sound negative equal to 10 times the exposure at which the negative H & D curve begins to be straight. For Eastman positive emulsion in the usual sound negative bath, the visual density at which the H & D curve becomes straight, is about 0.35 or 0.40 × gamma for values of gamma between 0.3 and 0.7.

It is seen from Fig. 1 that the density at the toe exposure is 0.20. The density for the unmodulated negative track which the standard recommendation calls for is then 0.70 visual diffuse (corresponding to a visual transmission of 20 per cent). This setting of the negative exposure means that 90 per cent modulation of light-valve spacing will not reduce the exposure beyond the lower limit, nor increase the

exposure as far as the upper limit of the straight line. The importance of being able to use a high modulation of negative exposure will be evident when we come to discuss noise reduction.

Fig. 11 exhibits an over-all construction on the same basis as that in Fig. 8, except that the lower right-hand quadrant is occupied by the curve of Fig. 1. Printer lines are drawn such that for one of them a negative unmodulated exposure equal to 10 times the toe exposure

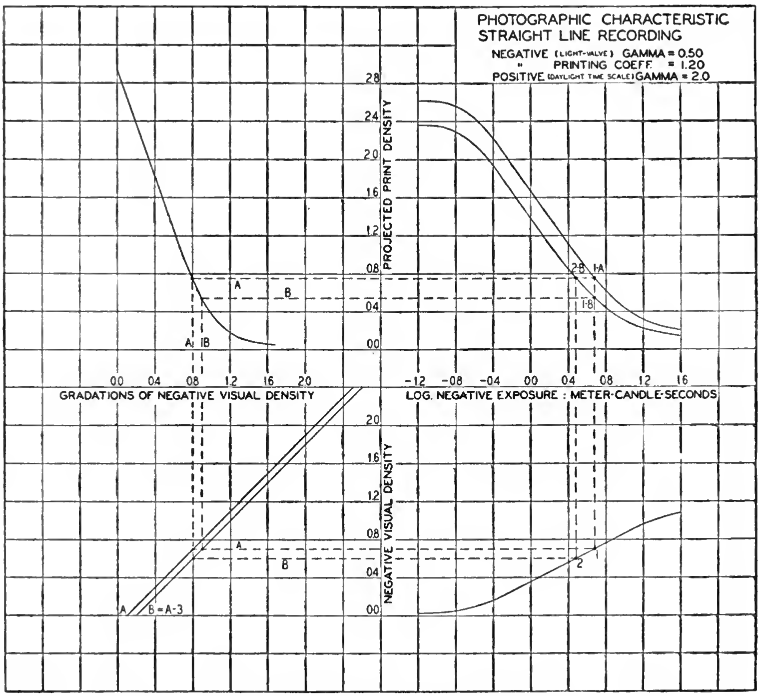

FIG. 11. Straight-line recording; over-all gamma = 1.4.

shall appear as a positive projected density of 0.75; for the other, an unmodulated negative exposure 6.3 times the toe exposure appears also as a positive projected density of 0.75.

The processing represented by Fig. 11 is commercially practicable and produces successful sound records. The over-all print curves in the upper right-hand quadrant are also adapted to pictorial requirements; in this case the sound is not in conflict with the picture.

The final print curves of Fig. 11, translated into projected print

transmission *vs.* negative exposure, are drawn in Fig. 12. For convenience the negative exposure is given in terms of the toe exposure. Just as in Fig. 9 in toe recording, we find here an S-shaped curve including a fairly straight portion. Curve *A* has this straight portion centered at a negative exposure equal to about 10 times the toe exposure, appearing as a positive projected transmission of 17 per cent. The central exposure of the straight-line part of curve *B* is about 6 times the toe exposure and again corresponds to a projected transmission of 17 per cent. We see here a point of resemblance between toe recording and this approximation to straight-line recording. In toe recording the negative exposure can vary from 0.30 to 0.45 meter-candle-seconds and produce a successful sound record, if the unmodulated negative exposure is in each case printed to a positive projected transmission of 42 per cent. In the straight-line record the negative unmodulated exposures may vary between 6 and 10 times the toe exposure, provided the projected transmission of the unmodulated positive track is made 17 per cent. Whereas in the toe record negative modulation must be restricted, say, to 45 per cent, in the recording represented by Fig. 12, 70 per cent negative modulation can be used without overstepping the straight-line limits of the final curve.

The two curves of Fig. 12 show approximately the same volume for 70 per cent modulation of the average negative exposure. This volume is proportional to 0.27 (average of *A* and *B*) whereas the volume of the toe record is proportional to 0.44 (Fig. 9), a difference in output of 4.2 db. in favor of the toe record.* Offsetting this is the difference between the projected noise levels to be expected from the unmodulated positive tracks of the two types of record. Within the limits of 10 and 40 per cent projected unmodulated transmission the noise amplitude, combining the noise contributions of negative and positive, is proportional to the projected positive transmission. There is indicated for the toe record a noise level 7.8 db. higher than that of the straight-line record. This difference corresponds to the 42 per cent transmission of Fig. 9 compared with the 17 per cent transmission of Fig. 12.

For both types of record the tolerance of negative unmodulated exposure may be interpreted as a tolerance in emulsion speed or in bromide concentration of the developer, or in intensity of light source.

* 4.6 db. if we are generous to the circles of Fig. 9.

From the point of view of the negative record it is, strictly speaking, a tolerance in the location of a point on the H & D curve.

VII. APPLICATION OF NOISE REDUCTION

The standard noise-reducing equipment closes the light-valve to a predetermined spacing when there is no input signal. When a signal current arrives at the light-valve terminals, provision is made to increase the spacing sufficiently to accommodate the incoming signal with adequate margin. It is not the purpose of this paper to discuss the adjustment of noise-reduction equipment, but to inquire what noise reduction may be expected of toe and of straight-line records without impairment of quality. The requirement should be adhered to that the negative exposure shall not fall below the limit of the straight line of projected print transmission *vs.* negative exposure.

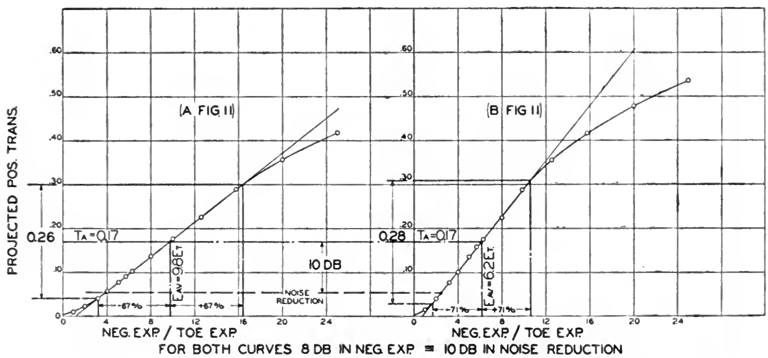

FIG. 12. Straight-line recording; sound reproduction characteristic.

As a basis for comparison let it be assumed that the valve closure shall in each case be such that an incoming signal 20 db. below the level, which fully modulates the valve at its standard spacing, shall not drive the negative exposure below the straight-line limits of Fig. 9 and Fig. 12, even if the noise-reduction equipment should fail to reopen the valve as rapidly as this incoming signal demands. At the normal valve spacing of 1 mil a sine-wave signal causing 100 per cent modulation changes the valve spacing by 1 mil above and below its unmodulated value. A sine-wave signal 20 db. lower than this full modulation opens and closes the valve by 0.1 mil, and it is this rapid movement in closing which must not reduce the negative exposure below the prescribed limit.

In the toe record, where 45 per cent modulation of negative exposure is permissible, the noise-reduction device may close the valve spacing to 0.65 mil, in which case a further decrease in spacing of 0.1 mil will not go outside the straight-line limit. Examination of the curves of Fig. 9 shows that this closure of the unmodulated valve spacing to 0.65 mil brings about a reduction in positive projected transmission equivalent to lowering the projected noise level by 6 db.

Treating the curves of Fig. 12 in the same way we find that closing the normal 1 mil valve to 0.4 mil is permissible, since a further closure of 0.1 mil just reaches the lower limit of the straight line. This is an 8 db. reduction in valve spacing and results in a 10 db. reduction of projected print transmission. It is therefore concluded that a noise reduction of 10 db. is possible in the composite* processing represented by Fig. 11 and Fig. 12.

The above conclusion regarding straight-line recording of this type has been often verified. Experimental toe records with the light-valve were made with adjustments of the noise-reduction equipment resulting in 9, 10, and 11 db. reduction of projected noise, showing in each case a distinct deterioration in quality and distortion of volume relations. These experiments roughly substantiate the statement that a 6 db. reduction in noise is all that can be expected of the toe record without incurring quality loss.

Compared with the straight-line the toe record has the advantage of greater signal volume, but this is offset by its narrower range between signal and noise level without noise reduction, and the smaller amount of noise reduction applicable without distortion.

In actual projection, the experimental toe record without noise reduction was found to be more than 1 fader step and less than 2 steps louder than composite straight-line records of the type here described. For the same level of dialog projection the ground noise of the toe record was somewhat more than 1 fader step louder than the ground noise of the straight-line record. Volume indicator measurements of dialog level and ground noise level showed for the toe record a range of 24 db. beween dialog and noise. If we can take 8 db. as the logarithmic difference between voice peaks and general voice level as read on the volume indicator, we have a range of 32 db. between the limiting swing of positive transmission and

* By "composite" is meant the processing of the sound positive to an over-all gamma greater than unity, in part offsetting this by appropriate use of the positive toe, the negative exposure being confined to the straight line.

the ground noise amplitude. This is an amplitude ratio of 40 to 1. If the double amplitude of modulation of projected positive transmission is 0.44, then the double amplitude corresponding to the ground noise is 0.011. This is a variation of less than 3 per cent of the average projected transmission shown in Fig. 9. If the noise were due exclusively to the film itself the variations in transmission corresponding to the ground noise would be almost imperceptible to the eye.

VIII. CLASSICAL STRAIGHT-LINE RECORDS: OVER-ALL GAMMA = 1.0

In the composite straight-line record of Fig. 11 and Fig. 12 the indicated limits of negative exposure in both curves *A* and *B* are within the limits of the straight-line part of the H & D curve. The over-all gamma is 1.4 and by itself would result in a curve of projected print transmission increasing more than proportionally to the negative exposure. This curve, convex to the axis of negative exposure, is partially rectified by printing on a portion of the positive toe. No use is made of the negative toe; this would exaggerate the convexity of the curve at the lowest negative exposures.

An over-all projected gamma of unity would result from a negative light-valve gamma of 0.36 in place of the negative curve of Fig. 11. The classical specifications require that only the straight-line part of this curve be used for the negative exposure and that it be printed to lie wholly within the straight-line part of the projected print curve.

Since for a Cinex gamma of 2.1 the printer curve is seldom straight beyond a visual density of 2.4, the maximum scale of negative densities printable on the positive straight line is 0.74 (see printer curve of Fig. 8 or Fig. 11). For 90 per cent modulation of negative exposure, confined to the straight-line portion for gamma = 0.36, the negative density range is $0.36 \times \log 19 = 0.46$. There is, therefore, a latitude of 8 printer points in printing this negative: $0.74 - 0.46 = 0.28$, and 3 printer points correspond to 0.10 in negative visual density for a printing coefficient of 1.2.

Fig. 13 shows the projected printer curve rotated 90 degrees to the left and negative lines of slope 0.36. These lines are of such length as to cover a range of 1.28 in log negative exposure, corresponding to 90 per cent modulation of a central exposure equal to 10 times the toe exposure. The actual H & D curve of gamma = 0.36 begins to be straight at a visual density of 0.14; for convenience the lines drawn in Fig. 13 are located to represent the lowest and highest printer

points at which they can be printed without going outside the straight part of the printer curve.

At the right in Fig. 13 are the corresponding curves of positive transmission *vs.* negative exposure for the limiting printer points. Each of these curves is straight over 90 per cent modulation of the central negative exposure indicated. Comparison of the two curves shows the unmodulated positive projected print transmission to be 0.07 for the lightest print and 0.012 for the darkest print consistent with the requirement that the negative shall be printed on the straight-line part of the printer curve. The volume difference between these two prints is therefore about 15 db. The maximum permissible noise reduction is determined by the requirement that a signal 20 db. below full modulation of the normal valve spacing shall not cause the negative exposure to fall below the toe exposure; 14 db. re-

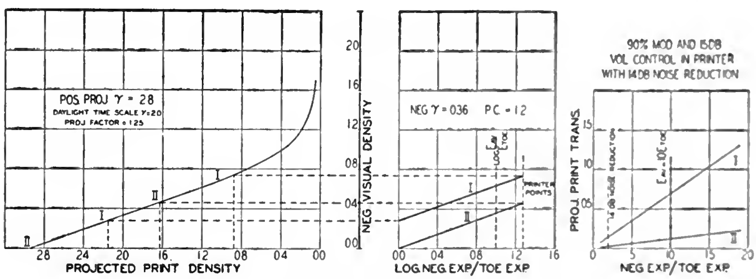

FIG. 13. Classical straight-line recording.

duction in valve spacing closes the valve to 0.2 mil. This is the maximum permissible and corresponds to 14 db. reduction in ground noise.

The signal volume to be expected from the lighter of these prints is more than 6 db. lower than the volume obtained from the composite record of over-all gamma = 1.4 and negative modulation 70 per cent. At the same time the noise level is more than 7 db. lower (unmodulated projected transmission of 0.07 compared with 0.17). The volume range between signal and noise is therefore about 1 db. greater in this record than in the composite.

IX. PROJECTION LEVELS OF LIGHT-VALVE RECORDS

The types of light-valve records discussed may be called toe, composite, and classical. Each with its appropriate negative exposure, negative modulation, and printer point is capable of giving excellent

sound reproduction. Only with the third type, the classical record, is it possible to control signal volume over a considerable range without distortion by choice of printer point. This will be clear from an examination of Fig. 9 and Fig. 12. It will be evident that for both toe and composite types, varying the printer point on a given average negative exposure will involve distortion unless the negative modulation has been narrowly restricted. For practical reasons only the lightest possible print of the classical record would be produced for theater use.

The numerical estimates of signal volume given for the three types of record show the toe record to be approximately 1.5 fader steps louder

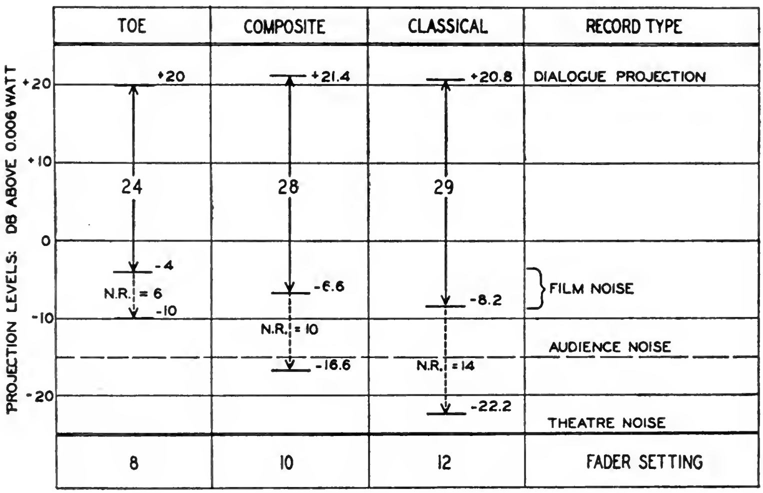

FIG. 14. Projection levels. Light-valve records.

than the composite and the latter 2 fader steps louder than the lightest print of the classical record. Signal-to-noise ratios are estimated as 24 db. for the toe,* 28 db. for the composite, and 29 db. for the classical. The permissible reduction in projected noise level is estimated to be 6 db. for the toe, 10 db. for the composite, and 14 db. for the classical.

In a theater of 500,000 cu. ft., seating about 2000 persons, the level of loud dialog projection is about +20 db. electrical power delivered to the Western Electric loud speakers. In such a theater

* Actual measured range of experimental toe record between dialog and noise.

the audience noise is at a level of −15 db., while the noise due to theater equipment in the empty house is about −25 db.*

Fig. 14 exhibits the comparative levels of dialog projection and of film noise with and without maximum permissible noise reduction for the three types of record when the fader is set to give approximately the same projection level for dialog. In a theater of the size assumed, the composite type of record would usually be projected at step 10 on the fader. The amplifiers would then deliver about +20 db. to the loud speakers. If fader step 10 is acceptable for the composite record, the fader could be set at 8 for the toe record and would have to be raised to 12 for the classical print restricted to the straight line of the printer curve.

Fig. 14 indicates that 6 db. noise reduction, the maximum permissible on the toe record, would leave the ground noise louder than the audience noise when the dialog level is +20. Ten db. noise reduction in composite records reduces the ground noise to a level below the audience noise, whereas the classical type of record with 14 db. permissible noise reduction reduces the noise level almost to that of theater equipment.

Of these three records only the composite type represents sound processing nearly like that of the picture and thus is the only type of processing which is possible for newsreel records, where sound and picture negative are made on the same film. In this case the usual picture development of both negative and positive can be used, requiring for its success a proper choice of sound track negative exposure, of negative modulation, and of printer light, possibly also a suitable filter when printing the sound negative. The considerations which have been set forth in this paper will enable any one to determine the proper treatment of the sound record.

X. CONCLUSION

(1) The commercial types of variable density sound records on film have been analyzed and compared with the classical specifications for distortionless sound reproduction.

(2) Sensitometric data have been discussed and it is shown that the product of positive and negative sensitometer gammas derived

* These levels are referred to 0.006 watt as zero level. Audience noise and theater noise are stated in terms of their equivalents in power input to the loud speakers.

from plots of visual diffuse density *vs.* log exposure is not equal to the over-all projected gamma of the sound track.

(3) The method of constructing the over-all characteristic has been described.

(4) The noise reduction applicable without distortion has been considered for each type of sound record.

(5) The projection levels of dialog and ground noise with the relative fader settings have been estimated with reference to an average theater.

In any sound film processing we have to consider the positive and negative development, the negative unmodulated exposure and percentage modulation, and the exposure of the unmodulated positive track. Fixing the positive and negative gammas leaves us free to choose the negative exposure and the printer point. In the toe record there is found to be a considerable latitude in the location of the negative unmodulated exposure on the negative H & D curve. For all negative exposures within this latitude there is one optimum density for the positive print. Similarly in straight-line records of over-all gamma = 1.4, there is a wide latitude in choice of negative exposure, again with a definite positive density for a successful print. In each of the above cases there is a definite limitation on the percentage modulation of negative exposure: 45 per cent for the toe record where positive and negative gammas are each 2.0 by daylight time scale, 70 per cent for the composite straight-line record of negative gamma 0.50, positive gamma 2.1 by Cinex time scale. It is obvious that for composite straight-line records developed to other values of negative and positive gamma, there exist similar optimum combinations of negative exposure, negative modulation, and print density. It will be found that the combination suitable for the case considered in the text is also suitable for positive and negative gammas, each 5 per cent higher or lower than the particular values illustrated.

Increase in signal volume obtainable from the straight-line records, either composite or classical, is obtainable only by lowering the contrast to which the positive print is developed. Since this positive contrast is determined by the requirements of picture processing, louder variable density sound records must wait for a softer print development unless sound quality is sacrificed.

In Hollywood, in January, 1931, laboratory "X" used a sound negative developer giving a printing coefficient of 1.08. In this develop-

ment the light-valve gamma of 0.47 was easily obtainable on Eastman positive film. At the same time laboratory "Y" used a positive bath and a combination of filter and lamp in the printer, which gave a true printer gamma of 1.58. The negative of laboratory "X" printed at laboratory "Y" would result in an over-all projected gamma of unity. The unmodulated negative exposure could have been made 10 times the toe exposure, permitting 90 per cent modulation about this average. The printer point at laboratory "Y" could have been chosen for an unmodulated positive transmission of 0.25 visual diffuse. This would have meant a projected print transmission of 0.17, giving the same noise level as in the composite record described above, and a signal volume proportional to 0.30. The 90 per cent negative modulation would have been reproduced without distortion, the signal would have been 1 db. louder than in the composite record just mentioned, and 14 db. noise reduction could have been used without distortion.

The toe-record volume is not seriously affected by a slight variation in gamma, and is about 2 fader steps higher than the composite straight-line record, over-all gamma = 1.4. At the same time the signal-to-noise ratio on the toe record is decidedly less than on the composite straight-line record, and is limited by the maximum noise reduction applicable without distortion. Wherever signal volume is the first consideration, the toe record is preferable. In the usual case, however, the most important consideration is the signal-to-noise ratio. In this respect the advantage is decidedly with the straight-line recording.

Of the two straight-line types examined, the composite record more closely resembles the picture technic. The classical recording, over-all gamma = 1.0, is exceptionally suited to the processing of sound records which can be treated independently of the picture. In this case the same development can be used for the sound negative and the sound positive, resulting in an over-all projected gamma of unity with maximum signal volume of the sound print. When the sound negative is made on positive emulsion, toe recording is called for by light sources of restricted intensity, and has the advantage of saving the separate sound negative bath. Where a light source of sufficient intensity for straight-line recording is available, the advantages of the toe record are offset by the greater volume range between signal and noise which is obtainable on the straight line.

All things considered, the advantage lies with the straight-line rec-

ord. Although lower in volume than the toe record, it has inherently a greater volume range for the same standard of quality, and this advantage is still further increased by applying noise-reduction methods.

In the discussion just concluded nothing has been said regarding the frequency characteristic for the reason that the high frequency cut-off for any record is determined by a number of circumstances independent of the processing technic; nor has anything been said regarding the practical problems of photographic chemistry and developer maintenance which must be dealt with in order to insure the most successful use of the photographic emulsion and, in the particular case of the toe record, the greatest stability in the shape of the H & D curve. It has been assumed that a uniform development was available for each type of processing, which means that adequate precautions were assumed to avoid variation in bromide concentration and in activity of the developing agent. It is commercially possible to maintain the developer composition by appropriate boosting, but the improvement in development formulas for both picture and sound record processes is a chemical problem of major importance with which the present paper does not deal.

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A SHUTTER FOR USE IN REDUCTION OF GROUND NOISE*

E. W. KELLOGG AND C. N. BATSEL**

Summary.—*A system for reducing ground noise on variable area records was described by Townsend, McDowell, and Clark in February, 1931. The preferred method employs a shutter mounted on the recorder which intercepts part of the light and reduces the sound track to a width just sufficient at all times to accommodate the modulation. A commercial design of shutter has been developed for this system.*

A motor for actuating the shutter has been designed in which an iron armature moves in a direction parallel to the pole faces so as to change the areas rather than the lengths of the air gaps. Such a motor combines the special advantages of the moving coil type, namely, long throw and stability, permitting the use of a highly flexible spring, and the advantages of the iron armature type, namely, light field structure and large winding space. Electromagnetic damping is provided. The resulting motor gives full deflection on about 20 milliamperes and has the desired speed of action. It can be attached to the optical system of the RCA Photophone type PR-4 Recorder with no operations on the latter except drilling and tapping two screw holes.

A system for reducing ground noise on film records was described by R. H. Townsend, H. McDowell, and L. E. Clark, in papers read before the Academy of Motion Picture Arts and Sciences, and published February, 1931. The system consists essentially of reducing the area of clear film in the sound track. In a sound reproducing system employing photographic records, ground noise is caused principally from photoelectric cell hiss (shot effect), variations of light due to graininess in the film, and dirt and scratches on the film. The photoelectric cell hiss is roughly proportional to the amount of light entering the cell. Irregularities in translucency due to imperfect distribution of film grains are negligible with unexposed film, increase to a maximum when the density is such as to cut off half the light, and become less again as the transmitted light approaches zero. Noise due to graininess in the film is usually slight unless the normally clear part of the film is fogged or the nor-

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* Presented in the Symposium on Sound Recording at the Spring, 1931, Meeting at Hollywood, Calif.

** RCA Victor Co., Camden, N. J.

mally black part is thin enough to permit considerable light to pass. With proper recording and printing the dark areas are sufficiently dense to be a negligible factor in producing noise. The major part of such noise as is traceable to graininess is due to fog in what should be the clear area, and is reduced by diminishing the width of the clear area. The noise due to dirt and scratches is also roughly proportional to the amount of light passing through the film. With normal recording, half the width of the sound track, on the average, is black and half is clear. Noise might result either from transparent spots in the black area or from dark spots in the clear area. The former, however, are relatively rare. If the negative from which the print is made is in good condition, there are practically no clear spots in the blackened area of the print. Scratches and specks of dirt over the dark part of the track tend to make it blacker, and have little effect. On the other hand, a projection print rapidly accumulates dirt and scratches and these show up as dark spots on the clear area. If the clear area is reduced in width, a corresponding fraction of the sound produced by these spots is eliminated. On the average, the energy represented by the ground noise is reduced in proportion to the reduced width of clear track.

While with 100 per cent modulation the full width of track is utilized, there are long stretches of comparatively small modulation during which the clear area in a standard recording is unnecessarily wide. L. T. Robinson, of the General Electric Co., proposed a method of reducing the width of the clear portion to an amount just sufficient to accommodate the modulation, by rectifying a portion of the audio-frequency current and passing the rectified current through the galvanometer in such a direction that the recording light spot would vibrate about a new mean position which is displaced from the center of the sound track. The result of this zero shift system is a sound print which appears as in Fig. 1. Experiments indicated that this accomplished the desired result, providing a substantial reduction in ground noise. C. R. Hanna, of the Westinghouse E. & M. Co., independently proposed and worked out substantially the same plan.

The system just described is open to the criticism that when the modulation is small the recording is displaced from the center of the track. In the case of imperfectly adjusted projectors it sometimes happens that the scanning beam does not cover the full width of the sound track and this might result in distortion or cutting off

of the small amplitude recordings. It would be safer to keep the recording in the middle of the track and cause a darkening of the unused portion of the track by bringing in the margin as shown in Fig. 2. H. McDowell, Jr., noted the drawbacks of the zero shift system and proposed the use of an auxiliary device in the form of a

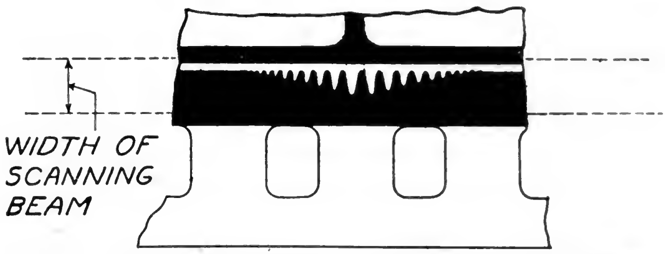

FIG. 1. Sound track made with variable bias of galvanometer.

shutter which would intercept part of the light used in recording, and give a sound print of the type shown in Fig. 2. A number of successful recordings have been made using McDowell's shutter. The advantages of this system were generally recognized and commercial designs of shutter equipment were undertaken.

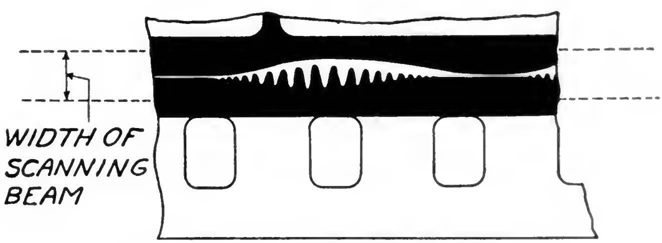

FIG. 2. Sound track made with shutter.

GENERAL REQUIREMENTS IN SHUTTER DESIGN

The original shutter employed a moving coil in a magnetic field. While this constituted an excellent driving motor it appeared to the writers that the moving coil was not necessarily the best choice of driving system. It has two drawbacks. The air gaps are necessarily long, and if a strong field is to be provided it requires either an electromagnet or a very large permanent magnet. In the second place the space available for the coil is generally small and it is difficult to put on enough turns of wire to make the device work directly

from the plate current of a moderately small radiotron. The features of the moving coil drive which have given it preëminence in the loud speaker field are: (1) freedom from instability, permitting an extremely flexible mounting which enables the loud speaker to furnish good response at very low frequency, and (2) low inductance, favoring the response at high frequency. Neither of these factors applies in anything like the same degree in the case of the shutter. A moderately stiff mounting spring would be employed since the shutter must be spring controlled rather than inertia controlled in order that the same current may produce the same deflection whether that deflection is reached quickly or slowly. Very low inductance is not essential, for the shutter need not respond at high frequency. Its movements must be too slow to produce perceptible sound in the reproducing system. Assurance against too rapid movements of the shutter is afforded mainly by filters in the electrical circuit between the rectifying system and the shutter. Inductance in the shutter winding may be considered simply as part of the electrical filter system. In view of these considerations it appears that if a reduction in field magnet requirements can be obtained at the price of somewhat stiffer springs and of increased inductance in the armature winding, such a change is desirable. If, in addition to a lighter field magnet, greater winding space can be obtained, this would be a further advantage.

The balanced armature type of motor, widely employed until recently for loud speakers, offers the advantages of short air gaps (and therefore light field magnets) and of less limited winding space, these features having been obtained at the cost of high winding inductance. Stability problems, however, impose serious limitations on the design of all magnetic motors in which an iron armature moves toward and away from the poles of a magnet. The armature mounting must be very stiff in order to hold the armature in the central position, and in view of the short gaps, only very small movements can be tolerated. The stiff mounting limits the sensitivity and the small permissible throw requires that the shutter vane be mounted on the end of a very long arm to obtain the required movement. This movement is of the order of $^1/_8$ inch in the case of the shutter for mounting on the optical system of RCA Photophone recorders. Such a long arm means that considerable mass must be moved, which tends to make the action of the shutter sluggish in spite of the stiff spring.

Consideration of the principles of design of electric generators and motors leads to the conclusion that a third type of motor offers the advantages of the moving armature construction without its drawbacks, namely, one in which an iron armature is employed, but in which the air gaps change in area instead of length.

It is of interest to note that in the design of electric motors the formula for the force per unit length of conductor applies without modification whether the conductor is on the surface of a smooth armature or in the bottom of a deep slot. The conductor in the bottom of the slot is not itself in a strong magnetic field and yet motor designers employ the familiar formula $F = \frac{Bli}{10}$ for the force developed. By winding the armature conductors in slots it has been possible to increase the winding space and at the same time shorten the air gap, thus reducing the excitation requirements. By way of illustration compare the field structure of one of the old Edison bipolar dynamos with that of a modern motor. These advantages in the design of motors have been secured at the price of increased armature inductance.

As a further illustration of the principle involved, consider the case of a single conductor in a magnetic field. The formula for the force exerted on the conductor does not consider the length of the air gap in which the conductor is placed, although the longer the gap the smaller is the change of field intensity produced by the current in the conductor. If a conductor carrying 10 amperes is in a gap of 0.5 cm. length having a field intensity of 10,000 gausses, it will increase the flux density on one side by 4π gausses or to 10012.6 gausses and reduce it on the other side to 9987.4 gausses. The same current in a conductor in an air gap 0.25 cm. wide, having the same initial field intensity, would increase the flux density on one side by 25.2 gausses or to 10025.2 gausses, and decrease it on the other side to 9974.8 gausses. Yet, the force on the conductor is the same, namely, 10,000 dynes per centimeter of conductor length. Any paradox in this situation disappears if we calculate the force on the conductor in terms of the side-wise push of a magnetic field. This push in dynes per square cm. is given by the formula $\frac{B^2}{8\pi}$ which is exactly the same formula as that for length-wise pull. The force on the conductor is the difference between the pressures of the fields on the two sides of the conductor, calculated over an area equal to the air gap length

multiplied by the length of conductor in the field. Thus for the 0.5 cm. gap the force is $0.5 \dfrac{(10012.6)^2 - (9987.4)^2}{8\pi} = 10{,}000$ dynes and for the 0.25 cm. gap the force is $0.25 \dfrac{(10025.2)^2 - (9974.8)^2}{8\pi} =$ 10,000 dynes, for l equal to unity. If the air gap length is reduced, the reduction in area of pushing field just compensates for the increased field differential produced by the current in the conductor. With the short air gap the main field can be produced with fewer ampere turns, and therefore a lighter field structure, but since the armature conductor causes more change in flux linkage, it shows a higher inductance. If the force on a motor conductor is calculated in terms

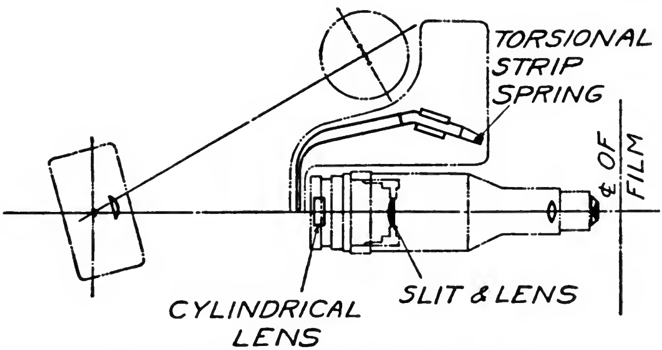

FIG. 3. Relation of shutter to optical system.

of the side-wise push of a magnetic field, it is found (neglecting reluctance of the iron) to be independent of whether the conductor is located on the surface of a smooth armature or in a slot. By putting the conductor in a slot a very short gap may be obtained without sacrificing winding space.

It appears that the advantages of a lighter field structure in a motor for the shutter can be obtained in a design which closely resembles the moving conductor type of motor but which employs a short gap obtained by placing the conductors in slots. It is obvious that so far as the principle goes, it makes no difference which part moves and which is held stationary. In the present shutter motor, the active conductors and teeth are stationary while the part most nearly corresponding to field pole face is movable.

MOTOR DESIGN

The construction of the shutter motor is shown in schematic form in Fig. 3. The resemblance to an electric motor appears greater if we think of the moving part as a single piece of iron. (Substituting aluminum for the central part is one of the liberties which can be taken in view of the limited movement.) Considering either air gap alone, the moving element corresponds to a field pole and the stationary pole pieces to a pair of armature teeth.

Two pairs of pole pieces are employed, each pair resembling an ordinary telephone receiver except that the permanent magnet imparts the same polarity to both poles of the pair. In the illustra-

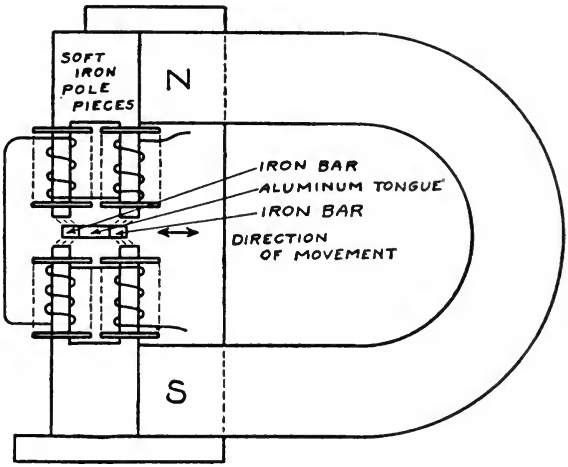

FIG. 4. General arrangement of magnetic shutter.

tion the two upper poles are both N and the two lower poles are both S in polarity. The moving element consists of a pair of small iron bars riveted to a duralumin tongue which is pivoted by means of a torsion strip in such a way that it can move readily in a direction parallel to the pole faces but can very strongly resist any movement which would tend to change the lengths of the air gaps. The duralumin tongue carries an extension in the form of an aluminum tube on the end of which is a flat vane. In the normal position each of the iron bars is about half way within the space between opposing pole tips. The magnetism exerts a force on the bar tending to bring it wholly within the space between the stationary poles. Thus the

bar on the left is pulled toward the left while the bar on the right is pulled toward the right. The condition of balance is not of the unstable kind which is encountered in magnetic devices in which the

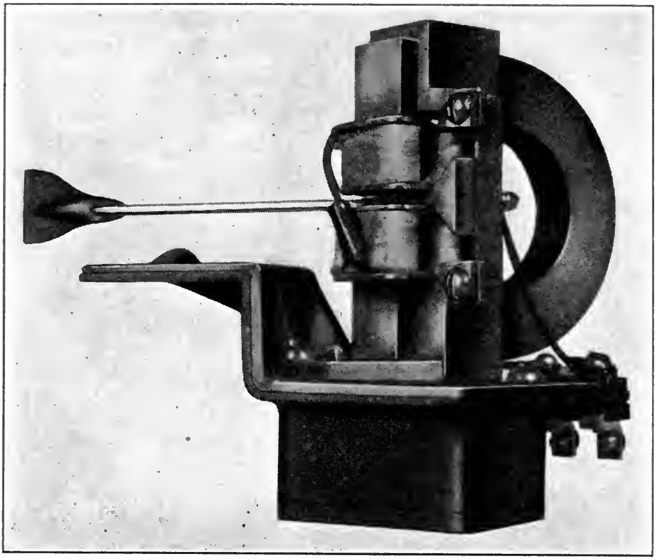

FIG. 5. Details of the shutter mechanism.

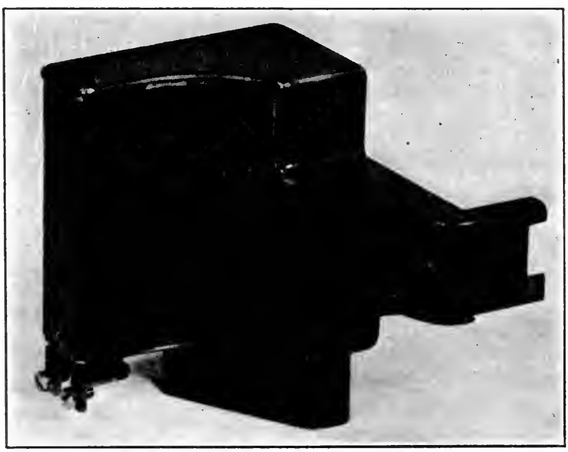

FIG. 6. View of shutter with cover in place.

air gaps change length instead of area. A very stiff spring is not required to hold the bars at the mid-position with respect to right or left movements. This being the case, strong forces are not required to produce moderate deflections and, therefore, good sensitivity is obtained. The coils are connected so that with current flowing in one direction through the four coils the poles at the left are strengthened and those at the right are weakened, thus pulling the movable element to the left, while a reverse current strengthens the poles on the right and weakens those on the left, causing the armature to move to the right. Fig. 4 shows in schematic form the manner in which the shutter fits into the optical system. Fig. 5 and Fig. 6 show the general construction and appearance of the shutter.

It is desirable in case of a rapid rise in modulation which causes a fairly quick movement of the shutter, that any oscillation which the latter tends to execute shall be quickly damped out. It was found possible to provide the desired damping electromagnetically by making the spool heads of copper.

The pole pieces are mounted in a bracket to which the torsion spring is attached. The total air gap spacing is fixed by the machining of the bracket. The adjustment of the armature in the middle of the space is accomplished when the torsion spring is clamped. The cover provides practically complete protection for the delicate vane. A mechanical zero setting is not necessary. The shutter is operated directly by the plate current of a pair of UX-171A radiotrons, about 20 milliamperes giving a deflection of $^1/_8$ inch at the edge of the shutter vane. The amplifier circuit is so arranged that the current decreases as the modulation increases. The adjustment of the shutter, therefore, consists in regulating the current through the shutter to bring the shadow close to the middle of the sound track when there is no modulation. The gain of the amplifier is then adjusted so that the shutter is completely out of the way when there is full modulation.

The shutter is designed to be mounted on the optical system of RCA Photophone recorders Type PR4-B, with no operations on the optical system except drilling and tapping two holes for attachment screws.

DISCUSSION

A paper entitled "Noise Reduction with Variable Area Recording," by B. Kreuzer, describing the theory and application of the system of noiseless recording to which the

shutter described in this paper is applied, was published in the June issue of the Journal. These two papers were presented consecutively at the Spring Meeting at Hollywood, and the following discussion applies jointly to the two papers.

MR. FELSTEAD: Has the noise reduction system any effect on the laboratory technic of development?

SPEAKER: With variable area recording the laboratory processing is handled in the same manner as it was without the ground noise device.

MR. MACKENZIE: What is the volume range obtained between the full signal and the unbiased unmodulated track?

SPEAKER: Probably 40 to 45 db.

MR. MACKENZIE: Has it been measured?

SPEAKER: Not to the best of my knowledge, to any degree of accuracy. Many features are involved in a problem of that kind, such as house noise, *etc.*, and it is quite possible, employing a noiseless recording system, to operate at levels lower than that of the house noise. Such low levels are, of course, useless.

MR. SILENT: I would like to call attention to certain differences in noiseless recording effects when using variable area and variable density tracks. The variable area method of recording requires an application of electrical units to the electrical circuit and the addition of a mechanical unit to the recorder itself. The variable density method of noiseless recording requires the similar application of an electrical unit to the transmission circuit, but no additional attachment to the recorder itself, since the light valve used in recording performs a function in cutting off the light similar to that of the mechanical attachment in the variable area method. In the variable area method the light normally covers but one-half the sound track in order to provide means for modulation, and in addition a shutter cuts off the light which is not necessary to carry the required modulation. We can then plot, in the form of a curve, the noise which results from this track against the amount of light which passes through it (see Fig. 1 of discussion). The amount of light which passes through it we may regard, of course, as proportional to the width of the clear area. The narrower the track, the less the noise which results from the movement of the film itself in front of the photoelectric cell. The noise due to the cell is small compared with that due to the film. Now, if we cut the width of the track in half we find that the noise output is reduced by 3 db., and if we cut the width of the track in half again, we find that the noise is reduced 6 db. Obviously, we can change the amount of light which passes through the track, not by reducing the width of the track, but by increasing its density, as is done in the variable density system of recording. Suppose we plot the noise received from the variable density track against the amount of light passing through it, and, instead of decreasing the width, increase the density, we immediately obtain a curve having twice the slope. When we have reduced the amount of light to 50 per cent of the original value, we have a 6 db. decrease in the noise due to the track; when reduced to 25 per cent we have 12 db. reduction in noise. In the upper portion of the curve there is a slight discrepancy, since it is not linear above the 50 per cent point. That, however, is of no consequence in this consideration. Now, suppose we want to obtain on the variable area track a 10 db. reduction of noise. This requires that we reduce the width of the clear space to $^1/_{10}$ its normal width.

But suppose that in the variable density process we also wish to obtain a 10 db. reduction of noise. In this case we need only decrease the spacing of the light-valve by a voltage ratio corresponding to 10 db., which is 0.316. In other words, in the variable area method of recording we reduce the width of the clear space on the sound track to 0.1 its normal value for a 10 db. noise reduction, whereas in the variable density method we need decrease the spacing of the light-valve to only 0.316 its original value for a certain definite amount of noise reduction. We have 3 times as much space for the clashing of the valves in the

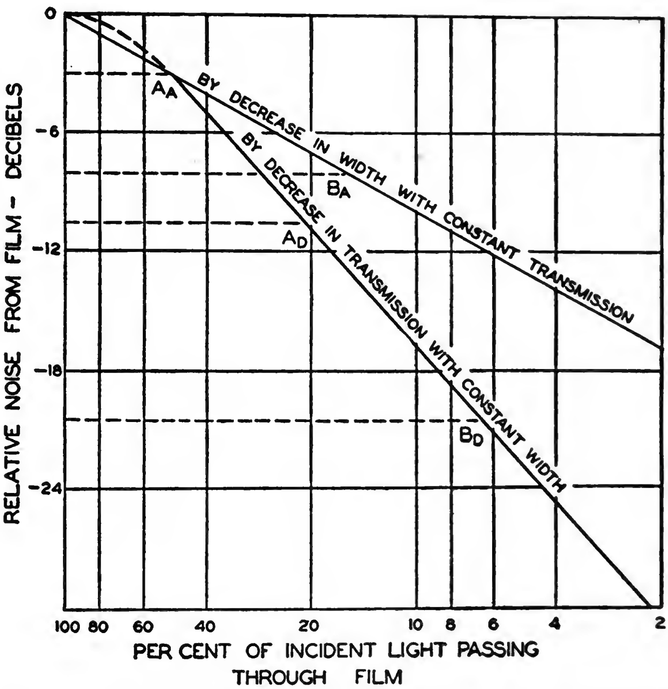

FIG. 1. Graph illustrating Mr. Silent's discussion on noise relations of variable width and variable density methods.

variable density method of recording as we have for overshooting of the vibrator in the variable area method of recording, which represents a 10 db. increase of margin against overloading of the recording unit itself.

MR. TOWNSEND: I would like to call attention to one point which I believe was clouded by the last discussion. In considering the variable area track, half the track is normally black. In other words, it is necessary to decrease the area of only one-half the track, because normally half the track is already black, and actual measurements would differ considerably from those given. In the variable density track it is necessary to reduce the light transmitted by the entire width of the track and not half of it.

MR. SILENT: The half width of the variable area track corresponds quite exactly to the carrier density of the variable density track.

MR. HUTCHINS: The figures given by Mr. Silent are not true for $^1/_{10}$ the width of the clear portion. The theoretical noise reduction, when the clear portion is reduced to $^1/_{10}$ its normal value, is 20 decibels, and the actual practical decrease is somewhat less than this value due to imperfect transparency and opacity of the track. I believe the actual noise present and the electrical power corresponding to that noise is directly proportional to the width of the sound track if the scanning beam across the area of the track is uniform. Variations from that are usually due to non-uniformity in the width of the scanning beam. Thus, non-uniformity in the scanning beam introduces distortion in the wave shape of the variable area track, but not in the variable density track.

MR. MACKENZIE: Perhaps Mr. Townsend has some measurements which will indicate the volume range obtained between a fully modulated dialog recording and a noise reading taken without modulation.

MR. TOWNSEND: I do not have those figures available. The best commercial results, if you permit that term, show a range extending about 45 db. above ground noise in a very quiet room. In a room in which the ordinary noise level is 10 db. or less, we find that the signal strength of a dialog modulated signal at a reasonable distance from a speaker, will increase to a limit of about 45 db., which is usable.

MR. SHEA: We have made quite an extended series of measurements in connection with the use of wide sound track for the so-called wide film. According to statistical theory, assuming the random addition of the noise currents it was expected that by doubling the track from, say, 100 to 200 mils, about a 3 db. increase of volume range would be obtained. While not very great, this is quite appreciable. We made measurements on tracks of various widths from 5 mils to 300 mils using a device which explored portions of the track. The theory checked out very closely over ranges of transmission as high as 50 per cent. In the variable area method the transmission is much higher. It may happen that conditions are somewhat different, but Mr. Silent's figures do hold, in so far as unmodulated track is concerned, up to a transmission of 50 per cent.

MR. SLAUGHTER: Speaking from the standpoint of one who uses the methods of reducing ground noise, I might say without hesitation that these methods have resulted in improvements in reproduction which are very gratifying. At the present time there are certain limitations in the matter of minimum noise conditions which prevail on the motion picture sets and the new methods of reducing ground noise are entirely capable of fully capitalizing on the noise reduction down to the limits set by studio noise conditions.

MR. CECCARINI: Mr. Slaughter's point of view is correct. In actual practice it does not seem feasible to reduce the noise beyond a certain degree because of the minimum noise conditions which prevail in motion picture sets, to which might be added the noise conditions in auditoriums and theaters in which sound is being reproduced.

With regard to recording sounds of low volume, it seems to me that in the case of the variable area method, the width of the track can be reduced to a very small value, thus realizing any degree of noise reduction without changing the wave shape of the sound being recorded. In fact, no relation exists between

wave shape and reduction of noise in variable area recording for a properly adjusted condition, excepting at the beginning of each sound—a fact which is common to both systems. With the variable density method using the double ribbon valve, there is a danger of short circuiting the ribbons unless precautions are taken. Furthermore, very low level sounds are recorded in the under-exposure region of the negative characteristic. This corresponds to distortion of wave shape, because the over-all contrast under these conditions would be far from unity. Moreover, the underexposure region of the negative corresponds to heavy density in the positive, and the spreading effect of heavy densities tends to obliterate these minute sounds, thus destroying linearity of volume. Two sounds, having a certain volume difference when heard in the monitor during recording, will appear to have a greater volume difference in the finished record. On the basis of these considerations the difference in "rate" of noise reduction pointed out in previous discussions, loses its real significance, and the controversy becomes one of "limits." Having had the opportunity to make extensive measurements with both systems, I am convinced that the reduction of noise by the variable area method can be extended to a limit far beyond that which is feasible with the variable density method, without depreciation of quality.

MR. HOPPER: With the advent of noiseless recording, all theaters which had been equipped with Western Electric equipment have been made the centers of extensive campaigns for reducing noise. The most common sources of noise in the theater are the ventilating systems, fans and other house equipment, and the projection equipment itself. Many theaters which are acoustically treated also have the projection booth treated to reduce noise. Recent developments in electro-acoustical devices in the Bell Telephone Laboratories have made it possible to determ ne the various noise levels very readily by experimental methods, and this has led to a study of means for reducing them.

MR. LAMBERT: Noiseless recording is apparently more valuable in re-recording than in original recording. In original recording, we do not usually have appreciable surface noise, but when this noise is doubled, or approximately so, in some instances in re-recording, it may then become objectionable. Our experience has shown that often noiseless recording methods will so reduce the surface noise of a re-recorded scene that it can be recut without using noiseless methods.

A SIMPLE CINE-PHOTOMICROGRAPHIC APPARATUS*

ARTHUR C. HARDY AND O. W. PINEO**

Summary.—*This paper describes a simple cine-photomicrographic apparatus built for the Bio-Cinema Research Laboratory at the Massachusetts Institute of Technology. The essential feature of the apparatus is an optical system which permits the separation of the microscope and illuminating system from the camera and its driving mechanism. The microscopist is thus enabled to use the microscope in the ordinary manner for visual work and has merely to insert the unit under the camera when the subject is ready to be photographed. In this way the same camera can be used interchangeably with a number of microscopes.*

The combination of a motion picture camera and a microscope results in an exceedingly useful tool for both instruction and research. A preliminary investigation of its possibilities was made here during 1919 and 1920 by one of the present authors in collaboration with Professor C. E. Turner of the Department of Biology. Films were made of protozoa feeding on bacteria, the hatching of ambystoma eggs, and many similar subjects which are either difficult to show to a large audience or which change so slowly that the action, to be appreciated, must be accelerated by the camera. The encouraging results of these early experiments led to the establishment of our Bio-Cinema Research Laboratory.

The purpose of the present paper is to describe a simple form of cine-photomicrographic apparatus, which was designed and built for this laboratory, and has been in use for approximately two years.

Since every biologist is necessarily proficient in the visual use of the microscope, an attempt was made in designing this apparatus to utilize as much of his present technic as possible. This was accomplished by employing an optical system which enables him to study the subject under the microscope in the ordinary manner and then, when satisfied with the appearance of the field, to swing the microscope quickly into position under the camera and make the exposure.

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*Presented at the Spring, 1931, Meeting at Hollywood, Calif.

**Dept. of Physics, Massachusetts Institute of Technology.

THE OPTICAL SYSTEM

The essential features of the optical system are shown in Fig. 1, The source of light is a "pointolite" lamp, *P*. The collector lens, *L*. images the globule of the lamp on the substage condenser, *SC*, which, in turn, images the collector lens on the stage of the microscope at *S*. The lenses, *O* and *EE*, represent the objective and eyepiece of the microscope, respectively. This much of the optical system is built as a unit, mounted on a board as shown in Fig. 2. It is sufficiently rigid to be carried about without materially disturbing the adjustments. When several investigators wish to use the same camera, a number of such units can be constructed at little additional expense. Each investigator can then use the microscope with which he is already familiar.

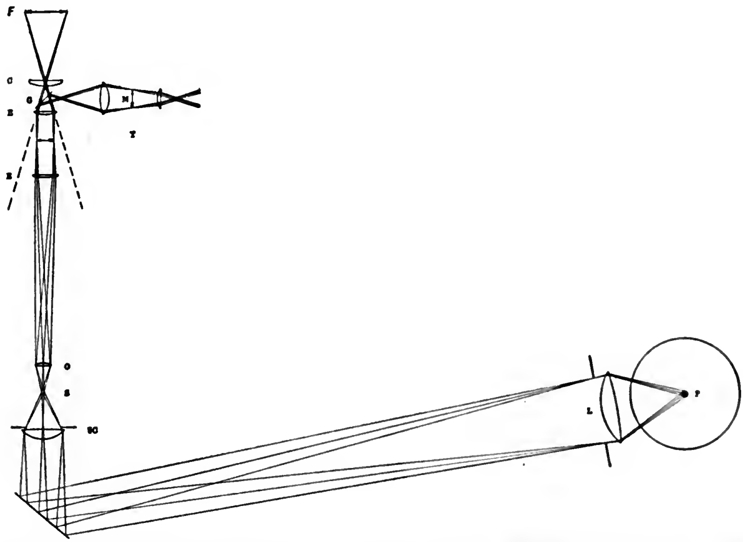

FIG. 1. The optical system of the cine-photomicrographic apparatus. The pointolite lamp *P* illuminates the stage *S* by means of the collector lens *L* and the substage condenser *SC*. The microscope objective is at *O* and the eyepiece at *EE*. The microscope is focused to form at infinity a virtual image which is re-imaged on the film *F* by means of an ordinary camera lens *C*. A piece of plain glass *G* and the telescope *T* take the place of the usual searcher eyepiece.

The remainder of the optical system consists of an ordinary motion picture camera objective, *C*, located so that it forms an image of an infinitely distant object on the film at *F*. In front of the camera lens

is a piece of plane glass, G, which acts as a beam-splitter. Some of the light is directed into the searcher eyepiece, T, which is, in effect, a low-power astronomical telescope containing the reticule, M, in the focal plane of the objective. When the microscope is focused to form an infinitely distant virtual image of the object on the stage, this image will be re-focused by the telescope in the plane of M. Since the camera lens C is permanently focused in its "infinity" position, the image will also be sharply focused on the film. The reticule is preferably ruled to indicate the limits of the field that can be photographed and the limits of any stops that may be placed in the camera. It enables the operator to keep the objects of interest near the center of the field as well as to maintain the focus of moving objects.

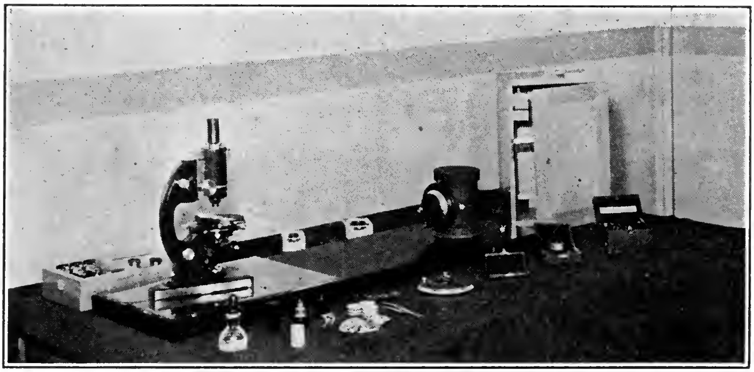

FIG. 2. A photograph of the microscope and accessory apparatus. The light source and microscope are mounted together on a baseboard so that the microscope can be used visually in the ordinary manner until a few moments before beginning the exposure.

The camera with its drive and timing mechanism is mounted on a track secured to the wall in such a manner that its height can be varied several inches by means of a screw ending in a crank, as shown in Fig. 3. The baseboard containing the microscope and illuminating system is supported on a table beneath the camera. The procedure which is followed in using this apparatus is first to remove the baseboard assembly to a convenient location while the subject on the stage is prepared for photographing. This part of the procedure usually consumes the most time. The advantage of being able to use the microscope independently of the camera is obvious. When the subject is ready to be photographed, the baseboard is placed on the table

under the camera, the height of which has previously been adjusted to suit the particular microscope. It is unnecessary to locate the microscope accurately with respect to the camera, any position being satisfactory that allows the light to enter the camera lens. The final focusing adjustment is made by looking into the searcher eyepiece.

Usually in cine-photomicrography, the lens, *C*, is omitted and the microscope is used for forming the real image on the film. A disadvantage of this method is that the adjustment of the microscope

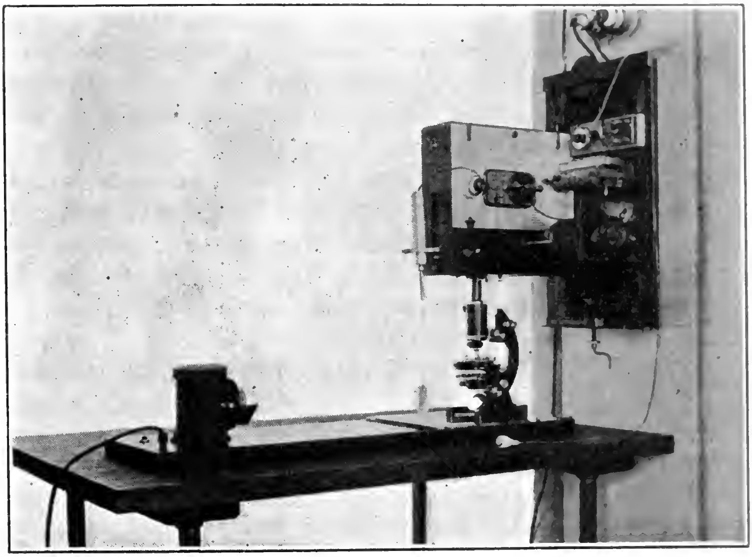

FIG. 3. A photograph of the microscope and camera assembled for photographing. The driving and timing mechanisms are shown at the side of the camera.

is very different for photographing than for visual use. To obtain the required real image for photographing, the correct procedure is to extend the draw tube until the eyepiece forms a real image of the image formed by the objective.* This adjustment is not simple and usually results in making the apparent magnification of the projected picture different from the apparent magnification of the visually used microscope. With the method described above, the adjustment of

* Although the same result is obtained by changing the focusing adjustment, this procedure is undesirable because objectives are corrected for a single working distance.

the microscope is the same when arranged for photographing as when used visually. By choosing the focal length of the camera lens properly, the apparent magnification of the projected picture is the same as that of the microscope. Let us assume an observer is seated in the audience at a distance d from the screen. If f_1 is the focal length of the camera lens, C, and f_2 is the focal length of the lens used to project the picture, the apparent magnification of the projected picture is the same as that of the microscope when

$$d = \frac{f_1}{f_2} D$$

where D is the distance from the projector to the screen. A common value for f_2 is five inches, so if f_1 is two inches, the magnification relationship is correct for an observer seated near the center of the auditorium. The advantage of being able to see the object under the proper magnification until a few moments before exposing is not fully appreciated without trying it. For the investigator having a limited amount of experience in the technic of cine-photomicrography, the fact that the projected picture always looks exactly like the view seen through the microscope furnishes the confidence that is necessary for obtaining uniformly satisfactory results.

Another important advantage of the method lies in the simplicity of the precautions that are necessary to avoid the effects of vibration. With optical systems in which the microscope forms an image on the film, vibration of the microscope with respect to the camera results in an equal displacement of the image on the film. If an attempt is made to prevent this by a rigid mechanical coupling between the microscope and camera, the driving mechanism sets the stage into vibration, an effect which is magnified on the film by the total power of the microscope. By causing the latter to form a virtual image at infinity, no ordinary amount of motion, either parallel or perpendicular to the microscope axis, will cause a displacement of the image on the film. According to actual test, the microscope can be displaced as much as one-quarter of an inch in either direction without causing the image to move perceptibly on the film or to go out of focus.

The most serious disadvantage of the system is the extra amount of glass that it contains. This reduces the light available for exposure by about 30 per cent and causes a very slight decrease in the maximum contrast. However, these disadvantages are much more than compensated for by the confidence that the simplicity of the system

gives to the investigator, particularly to those possessing only a slight familiarity with the technic of photomicrography.

MECHANICAL SYSTEM

The camera is driven by a motor through a set of change gears giving seven speeds, from twice normal speed to that at which one minute on the screen represents one hour under the microscope. Additional gearing for slower speeds would be cumbersome and inconvenient because of the very long periods of exposure at very slow speeds. This is avoided by using in the gear train a magnetically operated clutch which turns the "trick spindle" through one complete revolution at intervals determined by a timing mechanism. The timing mechanism consists of a master commutator of the drum type which rotates at a constant speed. Alternate segments are connected to an auxiliary commutator within the camera in the same manner as in the familiar three-way circuits used to control lights from either of two points. When the brush on the master commutator makes contact with one of the segments, a current is caused to flow through the clutch until the circuit is broken by the auxiliary commutator after the trick spindle has turned through a complete revolution. The clutch then remains inoperative until the brush on the master commutator makes contact with the next segment, when the operation is repeated. The interval between exposures is determined by the number of segments on the master commutator. In the apparatus as constructed, nine groups of commutator segments were arranged to provide for speeds which permit one minute on the screen to represent from fifteen minutes to six days under the microscope.

The magnetic clutch is operated directly from the 110-volt circuit, and consumes about 2 $^1/_2$ watts. It exerts a pull of about twenty-five pounds across an air-gap of one millimeter between the coil and the armature, and yet does not become appreciably warm if accidently left on indefinitely. A spring is arranged to force the armature against a braking surface when the current is cut off. Since the voltage is applied to the clutch only during the exposure of the film, the same voltage supply can be used for other purposes such as for turning on the exposing light during the time of exposure or, in the case of an arc source, for actuating a magnetic shutter between the microscope and the source. This is necessary when photographing certain subjects such as molds, which will not grow if illuminated continuously.

CONTROLLING THE EXPOSURE

When photographing at the higher speeds where the timing mechanism is not used, the camera is started and stopped by means of a push button at the end of a long cord which controls the action of the clutch. The illumination on the film is adjusted to its proper value by means of neutral filters inserted near the collector lens, C (Fig. 1). In making test exposures for determining the proper filter to use, it is convenient to be able to expose a single frame at any desired time. This is done by means of a four-way snap switch which coöperates with the commutator within the camera in such a manner that the trick spindle is caused to make a complete rotation for each snap of the switch. When photographing slow processes with the aid of the timing mechanism, it is usually desirable to have a few feet of leader showing the appearance of the subject before the action begins. In this case, the timing device, having first been adjusted to make exposures at the proper intervals, the leader is run off by depressing the push button; upon the release of the push button, the timing device assumes control for the remainder of the process.

CHARACTERISTICS OF DU PONT PANCHROMATIC NEGATIVE FILM*

D. R. WHITE**

Summary.—*Curves, photomicrographs, and spectrograms are presented and discussed showing sensitometric tests both with incandescent white light and with colored lights, rate of development characteristics, and color sensitivity and graininess for both du Pont special and du Pont regular panchromatic negatives.*

SENSITOMETRIC CHARACTERISTICS

The general sensitometric characteristics of du Pont regular and special panchromatic negative emulsions are shown in Fig. 1 and Fig. 2. Fig. 1 is a family of curves representing the rate of development of the special negative and Fig. 2 is a similar group of curves for the regular negative. For all of these curves, and in fact for all sensitometric data presented in this paper, the light source was an incandescent lamp operated at a color temperature of 2475°K. so arranged as to give an illumination of five meter-candles on the film as exposed in the sensitometer when no filter was interposed between the light and the film. The exposures were non-intermittent and were increased by factor two steps in time from one exposed area to the next. The sensitometer was of the sector wheel type having no unusual design features, and was driven at constant speed by a synchronous motor. With the particular wheel speed used, the longest exposure was 1.25 second and the shortest was 0.00122 second. The greatest and the least exposures, expressed as the product of time and intensity, were, therefore, 6.25 and 0.0061 candle-meter-second. These values are shown on the curves by their logarithms which are, closely, 0.8 and $\bar{3}.8$, respectively.

The development was carried out in a borax metol formula.[1] The developer was highly agitated during the development, a procedure which tends toward reproducibility of results but which also tends toward higher gammas at the shorter times of development

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Du Pont-Pathe Film Mfg. Co., Parlin, N. J.

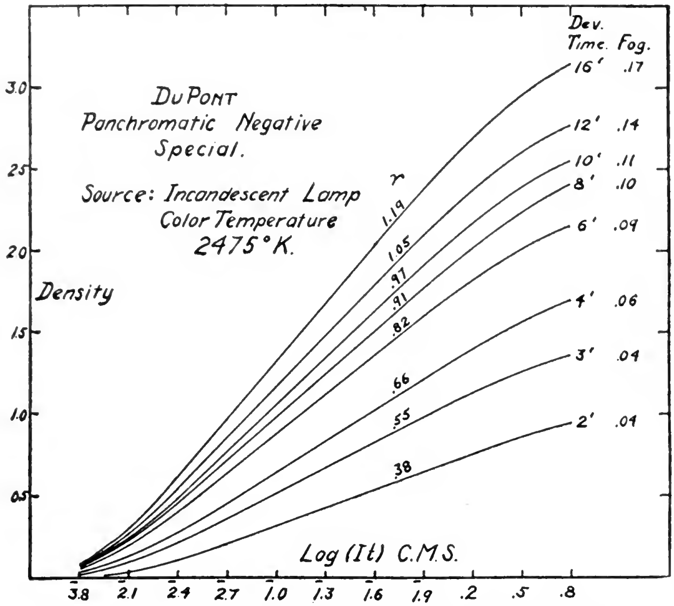

FIG. 1. Rate of development curves for du Pont special panchromatic negative.

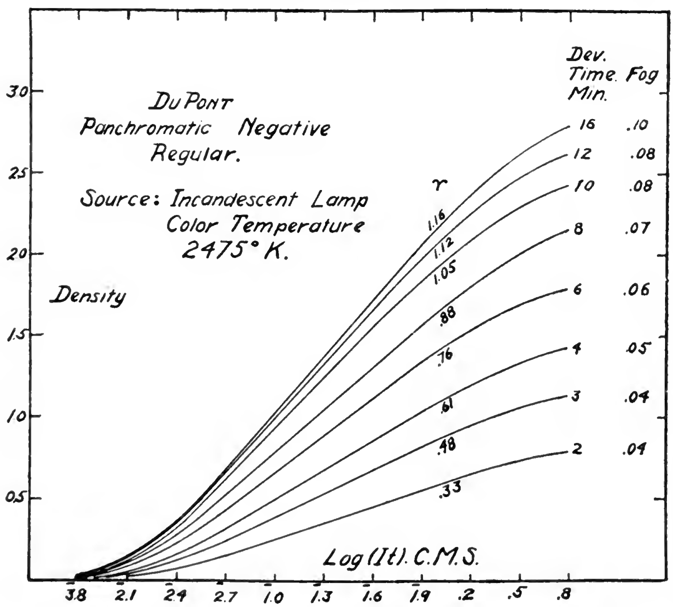

FIG. 2. Rate of development curves for du Pont regular panchromatic negative.

than would be obtained in some laboratories. Very similar curves would be obtained in any other satisfactory negative developer, although the time taken to reach any specified gamma would ob-

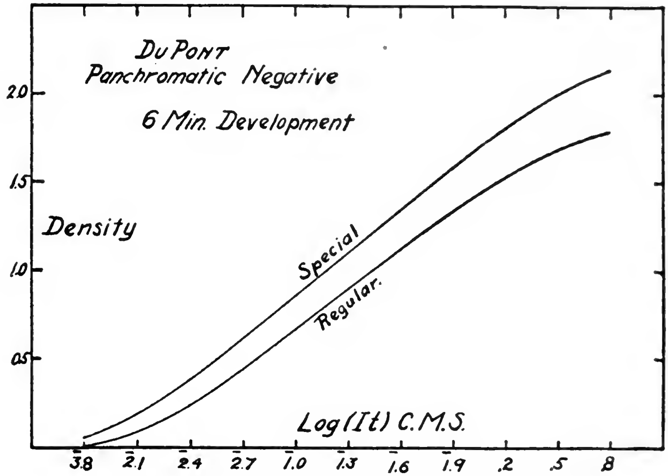

FIG. 3. H and D curves of du Pont panchromatic negatives.

viously depend upon the developer chosen, the temperature at which it was used, and the degree of agitation during development.

The two families of curves in Fig. 1 and Fig. 2 show that both

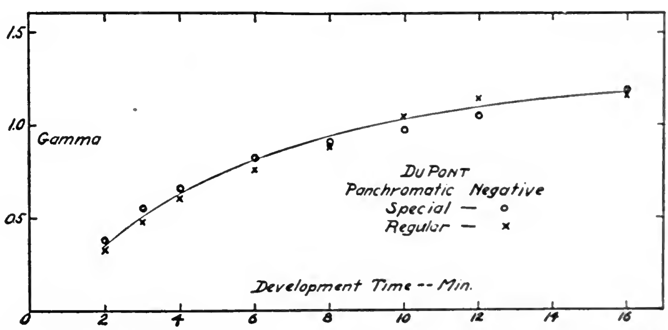

FIG. 4. Time-gamma curve for du Pont panchromatic negatives.

films are capable of producing gammas somewhat higher than unity, thus having potential contrast-giving possibilities beyond the normal requirements for negatives produced under present practices.

The greater densities produced on the special negative by corresponding exposures and developments of the two films show the greater speed of this special stock. To present this more clearly, Fig. 3 shows the curves for 6 minutes' development plotted together.

The gamma values taken from the curves of Fig. 1 and Fig. 2 are plotted together against the time of development in Fig. 4. Since the two sets of points fall so close together, only one curve was drawn to represent the time-gamma relationship. This curve represents the time-gamma relationship for only one developer and one set of developing conditions, but no large difference in the time-gamma curves for the two stocks is to be expected in any commercial negative developer.

COLOR SENSITIVITY

The completeness of the color sensitivity of these two films may be seen from the spectrograms shown in Fig. 5. Spectrogram A is for the special negative and spectrogram B for the regular film. These spectrograms were made on a small Hilger grating spectrograph, using a ribbon filament lamp as the source, with a neutral wedge over the slit, and do not readily yield quantitative data as

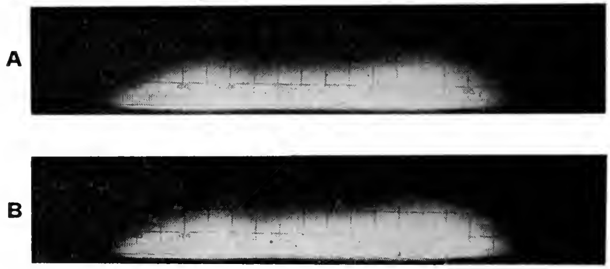

FIG. 5. Spectrograms on du Pont special (A) and regular (B) panchromatic negatives.

to speed or contrast values. The source used, an incandescent lamp, emphasizes the red end of the spectrum in proportion to its importance for photography with sets lighted by incandescent lamps. From the point of view of over-all film speed the blue is relatively more important and the red relatively less so, when pictures are taken in sunlight.

Further information concerning the color sensitivity of the two films may be obtained by a study of the curves shown in Fig. 6.

Here the curves marked "White" represent the density *vs.* log E relation for the unscreened incandescent lamp, which was operating as usual, at a color temperature of 2475°K. In this plot, E is expressed in arbitrary units as only relative values are of interest here. The curves marked "Red" represent the results obtained when this light was screened with a Wratten A filter. Similarly the curves marked "Green" and "Blue" show the data obtained with the B and C filters, respectively. It is interesting to note that the red filter transmits 40 to 45 per cent of the light photographi-

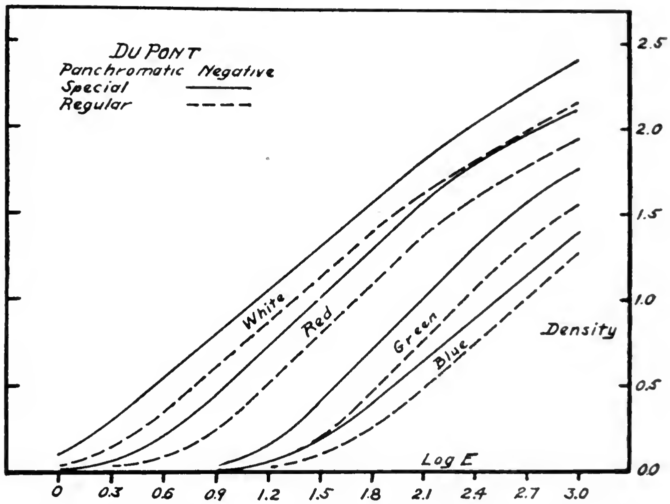

FIG. 6. H & D curves on du Pont panchromatic negatives, exposed to light as indicated below.

White: unscreened incandescent lamp operating at color temperature of 2475°K.; red: screened by Wratten A filter; green: screened by Wratten B filter; blue: screened by Wratten C filter.

cally effective on either stock, while the green filter transmits only about 9 per cent and the blue filter about 5 per cent of such effective light. Of course, it must be borne in mind that these filters are not equally transparent at their points of maximum transmission, but these data serve to emphasize the importance of the red in photography with incandescent lamps. The fact that all four pairs of curves labeled White, Red, Green, and Blue, respectively, have the same separation between the numbers of the pairs shows that the relative color sensitivity of the two films is the same. The spectrograms of

Fig. 5 indicated qualitatively this fact which now appears quantitatively.

The filter factors for these films were determined by independent experiments and confirm the conclusion just drawn. These filter factors, for sunlight, are given in Table I. It should always be

TABLE I

Filter factors for the Wratten filters, designated by letter, for sunlit scenes, for both du Pont special and regular panchromatic negatives.

Filter	*Filter Factor*
K_1	2.2
K_2	3.1
K_3	4
G	5
F	10
A	7
B	16
C	12

borne in mind when considering such factors that the specification of the source is as necessary as the specification of the filter and the film. Hence, these values cannot be considered as highly precise since the specification "sunlight" itself is rather indefinite. However, experience has indicated that these factors are quite satisfactory for these films under normal sunlight conditions.

OTHER DATA

Photomicrographs of the individual grains in these emulsions are shown in Fig. 7. Fig. 7A is a photograph of the grains of the special emulsion and Fig. 7B of the regular emulsion. Both photographs were taken at the same magnification. Since it is not the individual grains but, in general, clumps of grains that produce the graininess of pictures as viewed on the screen, the curve of Fig. 8 is of more value than the photomicrographs in comparing the two emulsions. The unit of graininess is arbitrary, but if some standard is chosen relative values may be determined. Various instruments have been constructed to make such determinations. The results presented were obtained with an instrument designed by Conklin.[2] No significant difference in graininess appears between the two films, although the graininess of both is a function of the density, as appears from the curve.

Closely allied with the graininess of the emulsion is its resolving power. This was determined for both emulsions by photographing

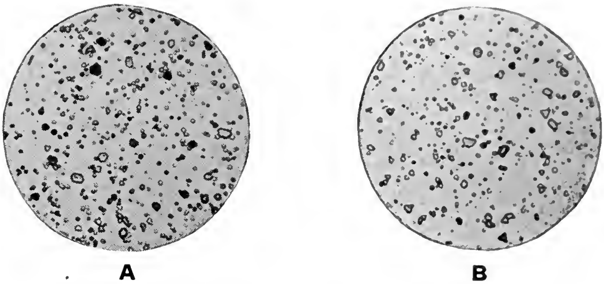

FIG. 7. Photomicrographs of the silver halide grains of du Pont special (A) and regular (B) panchromatic negatives.

a test object consisting of groups of parallel lines. This object showed great contrast between its dense and transparent portions.

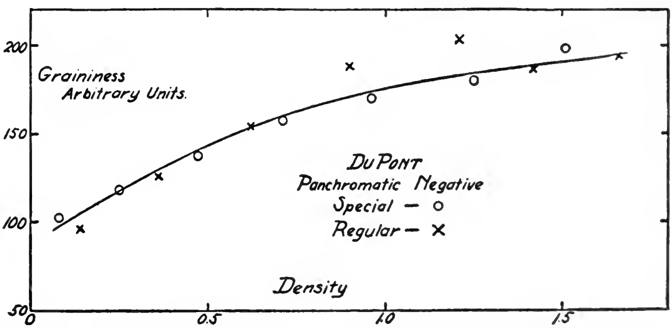

FIG. 8. Density-graininess relation for both du Pont panchromatic negatives.

The development of the negatives was carried to a gamma of 0.8. Under these conditions the special and the regular negatives both resolved 38 to 41 lines per mm.

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[1] MOYSE, H. W., AND WHITE, D. R.: *Trans. Soc. Mot. Pict. Eng.*, **XIII** (May, 1929), No. 38, p. 445.

[2] CONKLIN, O. E.: *J. Soc. Mot. Pict. Eng.*, **XVI** (February, 1931), p. 159.

THE HANDSCHIEGL AND PATHÉCHROME COLOR PROCESSES*

W. V. D. KELLEY**

Summary.—*This paper describes two old and much used color processes. In both of these the colors are applied as tints to the black-and-white prints. Handschiegl used the imbibition method and Pathéchrome the stencil system. Both systems have been used to produce release prints in commercial quantities.*

As worked by Handschiegl, his process is not what we usually term a natural color process. The most successful use for his system is in applying tints of color to the customers' own make of black-and-white prints. Good scenic prints and excellent work on titles are produced, but the method is most frequently used for giving "spotting" effects, such as in showing a red cross on the side of an ambulance, Will Rogers blushing in *The Connecticut Yankee,* or in fire scenes, which are also well adapted for coloring by this system.

In nearly every instance the customer furnishes the prints in the customary black-and-white stage. The color is applied mechanically, differing in this respect from hand coloring methods. The color tints, when blended, produce very beautiful effects.

Handschiegl started in the photoengraving and lithographic business and was very skilful at blending colors and producing satisfactory matrices. As this skill was largely individual, it died with him. The making of the master positive, from which the matrices were made, received Handschiegl's personal attention. They are obtained by printing back and forth until the parts to be colored stand out from the balance of the picture. The next step is the "blocking out" process, done by hand. This consists in painting out the parts not wanted or in shading those that are needed. From this master, the prints or matrices are made. The matrix print is developed in the usual way, then bleached in a bath that hardens the gelatin surrounding the silver particles, leaving the

* Presented in the Symposium on Color at the Spring, 1931, Meeting at Hollywood, Calif.

** Duchrome Film System, Hollywood, Calif.

clear portions soft as is possible. The bleached print is then immersed in a saturated solution of the dye in water, say, about two pounds of dry dye to five gallons of water, is next passed through blowers or wipers for removing surplus dyes and finally to a drying set of rollers. From such a matrix about two impressions of the same density are made and the matrix is again dyed. The life of

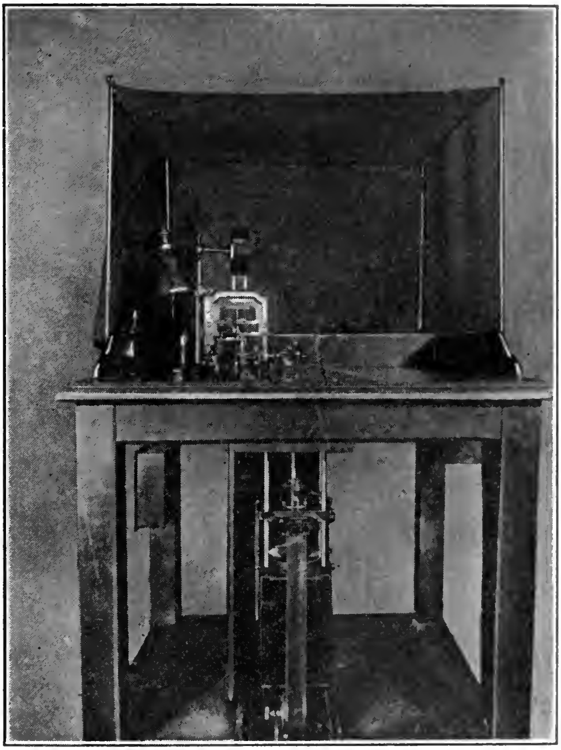

FIG. 1. Pathéchrome stencil cutting machine.

the matrix is 40 runs. The dyes used are acid dyes and not especially of Pinatype nature.

The machines for "imbibing" the dyes have three impression drums of about 12 inches in diameter with sprocket teeth that are not full fitting. Each machine has three drums, enough to use three colors in one passage through the machine. At each of the three drums provision is made for drying the matrix while the

positive continues over two or three of the impression wheels, according to the number of color tints required. The positive receiving the impressions passes from one color to the next, all three colors being applied one over the other and the blank is not dried until finished.

At the start of operations the positive which is to receive the

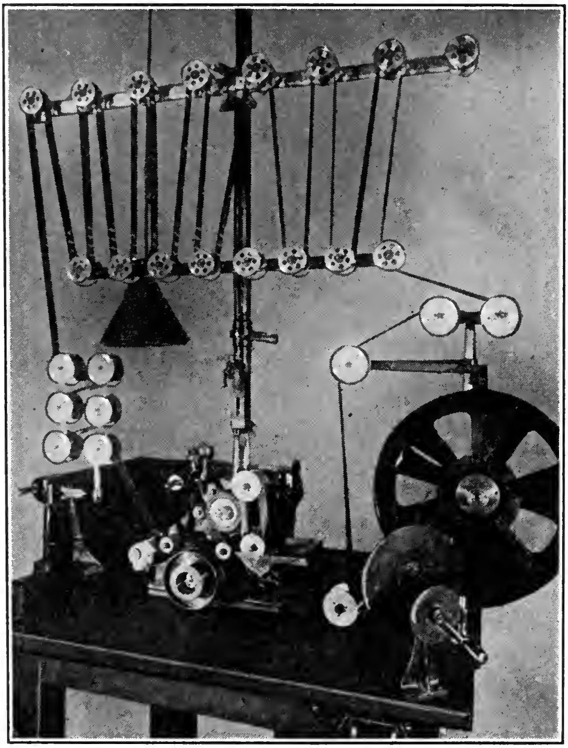

FIG. 2. Pathéchrome coloring machine.

colors is fed through damping means consisting of water and oxgall, receiving considerable wetting. Just before the two films are fed to the impression drum, emulsion to emulsion, each film is fed over a train of sprocket wheels designed to give tension for longitudinal registration, while lateral registration is attained from the adjustable lateral positions given the sprocket wheels. Discrepancies that might occur in registration are negligible, due to the color tints

being imbibed on black silver prints which tends to hide the faulty registration.

Attempts were made to apply color from color-selective negatives using this system. A black-and-white print was made from the negatives taken with a red filter. To this print were applied two complementary colors by means of matrices made from positives of each of the original two-color negatives. This produced some very excellent results, the main difficulty being that anything "black" in the subject received the greatest quantity of dye from the matrix which, when imbibed to the positive print, inclined to splash over where it would show the most.

At the speed of 360 feet an hour these matrices did not produce sufficient color on a blank for the transfers to make strong enough blacks to be used as prints without the keys, but for tinting, gave plenty of color.

The system is what is generally known as Pinatype. Blacks can be produced and the system is capable of making imbibed prints on a blank, but Handschiegl did not set up to do this type of work.

Attempts were made to colortone positive prints one color and then apply a complementary color by imbibition. To tone such a print it was not found possible to use any known color toning system without producing some relief or differential hardness on the surface of the print, even when printed to the back. For that reason it was not found practicable to make color prints in this way.

The use of basic dyes for the imbibition work is not wholly successful, the principal fault being lack of smoothness, and acid dyes were relied upon.

The matrices produce some relief in the surface but not as great as in the wash-out method. Positive prints of a quality suitable for making dupe negatives are the best. These were bleached in a bath composed of a copper salt, and bichromate, the latter controlling the hardness.

There is a great similarity in the finished product of Handschiegl and that of Pathéchrome. Both produce tints applied to positive black-and-white silver prints and both call for hand work in the preparation of the matrices. Both, also, can use the trained experience of lithographers, artists, *etc.*, as many of the colors are produced by overlapping the colors and securing blends.

The Pathéchrome matrices are cut by hand and are not at all produced by photography. A stencil is made from a celluloid strip,

one strip for each color, on a pantograph device which has a vibrating, electrically driven needle that cuts the celluloid away completely in the stencil film. The stencil film is carried under the electric needle while a companion picture film is carried in synchronism with it and projected up to about lantern size, over which the long end of the pantograph arm swings. An object to be traced is followed over the enlarged picture and the needle at the opposite end cuts away the celluloid in the normal picture. Each picture in a series is done in this manner for each of the colors that are to be applied.

The matrix film is then a series of openings through which a color is applied to the finished print. The celluloid to be cut for the stencil is a positive print from which the emulsion is later removed and the film cleaned. The show prints are made on a registering printer in which the feeding pins, in a step movement, draw both the negative and positive forward one frame at a time. About midway of the stroke, one of the feeding pins spreads sideways from the other, thus adjusting the films laterally. The prints are sometimes toned to produce one of the shades to be used.

In the Handschiegl process a photograph reproduces the matrix, while in the Pathéchrome process a stencil cut by hand does the work. In both cases, each frame is worked by hand, for in the Handschiegl method all parts not wanted are blocked out with color, by hand.

Coloring by Pathéchrome is much more rapid than by imbibition. The stencil and positive to be colored are brought into contact over a sprocket wheel while a velvet ribbon wipes a color through the stencil to the positive. This color ribbon is a loop of about one foot in diameter. A series of brushes feeds the dye to the ribbon, so that it does not receive too much of the colored liquid. The film passes through this machine at the rate of about 60 feet per minute.

SOUND PICTURES IN THE SOLUTION OF SOLAR ECLIPSE PROBLEMS*

F. P. BRACKETT**

Summary.—*The application of sound picture technic toward the solution of solar eclipse problems is described. Motion pictures of the shadow spot cast upon the earth by the moon during an eclipse are taken simultaneously with photographic records of time signals broadcast by radio. By coördinating the information contained in these photographic records of the shadow spot, the time signals, and identification marks on the earth, sufficient information is available for solving various astronomical problems such as determining with greater accuracy the distance of the moon from the earth, the relative positions of earth, moon, and sun, and to permit more accurate computation and prediction of eclipses. A method is also described of making a qualitative study of the variation of light intensity at points in the path of the shadow.*

In all the strange and beautiful phenomena of nature, I suppose there is nothing as thrilling and spectacular as a total eclipse of the sun; and yet, strange to say, very few really successful motion pictures of a solar eclipse have been made.

This is probably due to the fact that motion picture men and astronomers did not coöperate in the effort until within the last two or three years. Several attempts to obtain such pictures failed because the cameraman did not follow the counsel of astronomers in meeting conditions entirely different from those with which they were acquainted. On the other hand, astronomers, with all their experience in photographing celestial objects of all sorts, could not make a *motion* picture of a solar eclipse without the assistance of experienced motion picture men and their instruments.

In 1923, astronomers flocked to California to observe a solar eclipse. In organizing an expedition from Pomona College, we conceived the idea of taking motion pictures which would furnish a complete graphic record of the eclipse for scientific study, and at the same time be of popular and commercial value as a motion picture. A scenario was written which included all the dramatic features incident to the

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* Presented at the Spring, 1931, Meeting, at Hollywood, Calif.

** Pomona College, Claremont, Calif.

preparations, the voyage to the station, and the activities of the observers during the eclipse, as well as views of the eclipse itself. An agreement was made with a motion picture company to "shoot" the pictures. When the time came, however, they decided "to go it alone," with the result that neither they nor we got the motion picture, though other parts of our work were successfully done.

During the past two or three years a number of good cinema-eclipse pictures have been made, one of them, by the way, on a winter morning in New York. In every instance this has been accomplished by the earnest coöperation of producers and astronomers. I believe that we have only started on the road to success in this field.

A total solar eclipse occurs when the moon intervenes between the earth and the sun, and its shadow falls upon the earth. From any point in the shadowed area of the earth, one sees the sun covered by the black disk of the moon, its light being blotted out. But if one were looking down upon the earth from the moon, he would see a dark oval-shaped shadow moving rapidly across the earth's surface.

If the shadow-spot were small enough he might even see it all from the summit of a high mountain or from an aeroplane. Accordingly, Dr. Whitney and I organized another expedition from Pomona College, at the time of the total solar eclipse in April, 1930, to obtain motion pictures of this shadow of the moon upon the earth from an aeroplane, and to locate the shadow and time its motion with the greatest possible accuracy.

The result of this undertaking, if successful, would be that we should be able, by locating and timing the shadow, to determine with new accuracy the moon's distance from the earth, and so the relative positions of earth, moon, and sun; and hence, among other things of much importance, to permit more accurate computation and prediction of eclipses.

Stated thus briefly, the problem looks simple enough, and is easily understood; but it proved to be a quite an undertaking, involving hundreds of people and elaborate equipment.

The eclipse of April 28, 1930, was very unusual, and because of this unusual character, it was ideal for our purpose. The eclipse was very short, totality lasting only $1^1/_2$ seconds (the average duration of a total solar eclipse is two or three minutes), which was quite unfavorable for most observations. Its brevity was due to the fact that the shadow of the moon, cast by the sun, barely reached the surface of the earth, passing over a strip of a few hundred miles, and the shadow spot

along this line was very small—only $^2/_3$ of a mile across at its maximum.

It is a very curious circumstance that the size of the moon and its distances from the earth and the sun should be in just such a proportion that the length of the moon's shadow (the umbra) very closely approximates the distance of the moon from the earth, *i. e.*, about 240,000 miles. It varies a few thousand miles in length, so that sometimes the earth is within the umbra and we see a total eclipse, and sometimes it is beyond the umbra (*i. e.*, in the penumbra) and the eclipse is annular. It is still more curious and unique when these distances are so closely the same that the point of the cone-shadow just touches the earth's surface for so short a path and with so small a spot.

Computation indicated that if pictures were taken from a height of 12,000 to 15,000 feet above the ground this shadow-spot might be entirely contained in the frames of a motion picture with margin enough for identification of nearby objects.

Geometrically, of course, two points are needed to determine a straight line. Hence, to locate the central line of the path of totality (which for a few hundred miles is nearly straight) we required two well separated sets of positions of the shadow. This meant also that we required four stations, two on the ground and two in the air, two good motion picture cameras, and two powerful aeroplanes.

This is not the place to tell the long story of preparation—the preliminary computations, the study of lighting conditions, the investigating and testing of films, the securing of aeroplanes and cameras, the selection of stations, the building and adjustment of auxiliary instruments, the transportation to the stations and setting up of the instruments, the placing of a large pattern of identification marks over miles of desert floor—two or three months of intensive work.

In solving this problem not only the exact location of the shadow was needed, but the exact time of the spot-location for each separate picture. For this, very fortunately, we were able to use a method that would have been quite impossible during previous eclipses—that is, to use a sound-camera to record time signals on the film itself. Hence we had to provide either for an astronomical determination of time on the spot or for the broadcasting of time signals by an astronomical station, and this required a radio receiver in the aeroplane in addition to the camera.

To make a long story short, we established two regular ground

stations—one at Ramm's Ranch, near Camptonville on the west side of the Sierra Nevada range in Yuba county, Calif., and the other nearly 100 miles distant, at Honey Lake, north of Reno, Nev., on the east side of the mountains. Motion picture cameras for the graphic record of the eclipse itself and other instruments for the more customary eclipse observations were set up at these stations. A great deal of consideration was given to the matter of landmarks which could be identified in the pictures of the shadow. Huge crosses of canvas were suggested, and whitewashed areas and buildings, in addition to the natural features of the landscape. All these were used to some extent, but in the end we relied chiefly on pairs of 25,000 candle-power flares, suitably placed and set off by alarm clocks. By placing these pairs of flares, some parallel to the central line of the computed path of the shadow and some perpendicular to it, and by spacing them differently in certain patterns, we could identify any pair in any frame of the picture.

Eventually, two large planes, each with two experienced pilots, were placed at the service of the expedition. One was a tri-motored Fokker cabin plane and the other a large Fairchild army plane. The Fokker, assigned to the Ramm's Ranch station, was equipped with a first-class motion picture camera, and flew from Mather Field.

A place on the dry bed of Honey Lake was chosen as the base for the army plane. In this plane were installed the sound camera with its amplifiers and batteries and the radio receiver. Arrangements were made with the Navy Department to broadcast time signals each second during the period of totality for this region.

A number of test flights and exposures were necessary so that all the complex manoeuvers of observers and instruments could be tried out and coördinated, the pilot, for instance, handling the plane so that the camera could follow a train on a curved track. All this was accomplished from Clover Field where the instruments were installed in the army plane under Captain Stevens who commanded the plane, and who, being himself a skilled aerial photographer, aided the sound camera expert by operating the camera.

On the day of the eclipse heavy clouds covered both sides of the mountains throughout the period of the eclipse. Only through breaks in the clouds were glimpses of the pageant seen from the ground. From the air, the sight was marvelous indeed. The plane from Mather Field, finding clouds over Ramm's Ranch, flew westward over the predicted path, as had been planned in case of such a contingency,

and took pictures of the country below, though not quite sure of the shadow, battling with cold and exhaustion at an altitude of 19,000 feet. Interesting pictures they are, taken through scattered clouds, but the shadow of the moon could not be defined in them.

The flight of Captain Stevens and his two associates in the army plane was even more dramatic and, I believe, also historic. The story is recorded in Pomona College publications—how they waited under the clouds, all ready to go, until hardly an hour remained to reach the great altitude required; how at last a small clearing appeared, and they took off, pushing up through this hole, through a mile-depth of clouds, and then came out above them; how they climbed still higher until they reached 18,500 feet, just in time to swing into position as totality began; how they blanketed their instruments to keep them warm and themselves to keep from freezing; how they had to conserve their oxygen supply; how they saw the shadow appear in the distance and rush on toward them; how they beheld it appalled, not realizing at first what it was; how they got their pictures in spite of every difficulty; and how they came down at last, through the clouds, to a safe landing on the dry lake bed—a thrilling story as told by Captain Stevens and his companion, James W. Balsley.

For the first time in history those men saw the great shadow of the moon coming upon them with terrific speed across the surface—not of the ground, alas—but over the upper surface of the clouds. For the first time motion pictures were taken of this phenomenon as the shadow came and went.

Astronomically, of course, we were disappointed that the shadow was not seen upon the ground where its exact position could be determined, instead of upon the rough and billowy surface of clouds where its outline was too vague to be well marked in the film, although it may be readily followed on the screen. Great as our disappointment was at the time, we know now that, while leaving much to be desired, the expedition was far from being a failure, as I shall point out in a moment.

So far I have spoken of *one* of the two problems in which our expedition was chiefly concerned. Let me now, much more briefly, refer to the second problem.

In this we undertook to measure the intensity of the sun's radiation, especially the intensity of the sunlight itself, at a number of points in a line across the path of totality. Five such points some

500 yards apart were selected at Ramm's Ranch, in a line perpendicular to the computed central line. At each point an instrument was placed, consisting essentially of a photoelectric cell and amplifier, and a milliameter whose index marked the changes in intensity of light as the shadow passed over the point during the partial and total phases of the eclipse. All these milliameters, each connected by long lines to its distant photometer, were mounted upon a panel at a central station together with two timepieces, so that all these ammeter dials and clock faces could be photographed simultaneously by a motion picture camera—by two of them, in fact. In this way a continuous picture was taken showing the variation in light intensity at each point, and graphs were plotted for each point. The net of these curves, then, not only locates the path of totality, but tells much more as to the intensity of the radiation and illumination.

At the national meeting of the A. A. A. S. in Chicago, last August, where the work of this expedition was reported to the Astronomical Section, it was agreed that two things were accomplished that were quite worth while. The solution of two entirely new problems had been undertaken. In both cases a new technic was proposed and tried out, establishing a new method which might be tried again with good hope of success even though the conditions would not be so favorable again for perhaps a hundred years. Already we are considering a repetition of the experiment with the eclipse of August, 1932, in New England.

PRESIDENTIAL ADDRESS

DELIVERED AT THE OPENING OF THE SPRING MEETING AT HOLLYWOOD, CALIF., MAY 25, 1931

It is a pleasure to welcome you to this, the thirty-first convention of the Society. Our twenty-fifth convention was also held in Hollywood. Although that was only three years ago, by comparing our status then and now, we can realize how our Society has grown not only in size but in its value to the industry and the world at large. The comparison also emphasizes the magnitude of the changes that have occurred in the technic of producing motion pictures.

In 1927, the tools of production consisted largely of cameras using orthochromatic film and arc lamps. The year following, panchromatic film was introduced and was soon universally adopted. As a consequence of the improvement in photographic quality which resulted, the producers began to direct more attention to the technician because they saw that he is also a potential contributor to box-office values.

A study of the relative merits of arc and tungsten lamps for lighting sets was next instigated by the American Society of Cinematographers and the Academy of Motion Picture Arts and Sciences, and these experiments were concluded just prior to the Hollywood convention. The use of sound in conjunction with the motion picture was beginning to be discussed, but with many misgivings. Our Society staged the first demonstration of Photophone equipment in Hollywood, although the demonstration attracted but slight attention from the producers. Six months later the sound revolution commenced; there followed a mad scramble to build new stages and modify old ones, and in a relatively short time there was on the influx of a large army of skilled technicians to take care of the new equipment and procedure. In the short space of three years remarkable advances have been made in the technic of recording sound and in the making of motion pictures, and it is therefore fitting that we should hold our national convention in this center of production in order to exchange ideas and discuss our new problems and recent researches.

A wide gap of 3000 miles between the technicians in the East and those in the West, and an economic depression are, of course, not conducive to frequent meetings in Hollywood but I think it is highly important that the time intervals between our conventions in Hollywood should not exceed two years.

During the past six months our Society has undoubtedly made more progress than in any similar period of its existence. In January, 1930, an important milestone was passed when the form of publication of our technical papers was changed from the quarterly *Transactions* to the monthly JOURNAL.

A second milestone was passed in November, 1930, when our Society acquired an Editor-Manager and permanent headquarters at 33 West 42nd Street, New York, N. Y. The Editor-Manager, Mr. Sylvan Harris, is a graduate electrical engineer with extensive research and editorial experience and, in addition to editing the JOURNAL, has taken charge of much of the routine business formerly undertaken by the Secretary and committee chairmen.

Our Society has continued to disseminate an increasing amount of technical information through the medium of the JOURNAL. The quality and quantity of the technical papers has been maintained and an increasing proportion of these have dealt with fundamental principles which are so vitally necessary for the healthy advancement of the industry. Several new sections have been added, including those devoted to Patent Abstracts, Committee Activities, and Activities of the Academy. The readers have also been kept in touch with developments in foreign countries by means of translations of articles originally published in French, German, and Russian. The section devoted to abstracts of technical papers has been enlarged, due to the establishment of an organized staff of abstractors.

An Open Forum has also been initiated, through the medium of which readers may offer suggestions relating to the welfare of the Society, draw attention to problems requiring investigation, or make preliminary announcements of their technical discoveries. The circulation of the JOURNAL numbers about 1000 which is somewhat unsatisfactory. It is hoped that it will be possible to reduce the subscription price in the near future to permit of much more widespread circulation which it deserves.

The sections of the Society, having their headquarters in New York, Chicago, and Hollywood, have been increasingly active and have held local meetings at regular intervals, thereby drawing attention to new

problems and developments with a minimum loss of time and permitting more intimate discussion than is usually possible at the semiannual meetings of the Society.

It was with extreme regret that the Board of Governors resolved to disband the London Section. Refusal of the Board to accede to requests for reduced entrance fees, authority of this section to appoint Active members, and a non-budgeted expense account resulted in the resignation of the officers of the section, who, in turn, established the independent British Kinematographic Society. Fifty of the members of the London Section retained their membership in our Society. We wish the new Society every success and will collaborate to the fullest extent on technical matters.

The various standing committees have worked untiringly and with regularity, as contrasted with the somewhat spasmodic efforts of many previous committees. The members of the Progress Committee are distributed throughout the world, and their submitted reports result in making the Progress Report a representative picture of world developments. The fine papers program before you is the result of organized solicitation by the Papers Committee, which has been successful in securing advance abstracts of all the papers for publicity purposes. The Standards Committee has finally arrived at a recommended standard for wide film and has prepared a glossary of motion picture terminology which will be published in an early issue of the JOURNAL.

The excellent arrangements for the present Convention are an indication of the efforts of the Convention Committee. The Publicity Committee has consistently secured excellent trade notices, while through the efforts of the Color and Paper Committees, it has been possible to arrange for the color symposium during this Convention.

The Historical Committee has published papers in the JOURNAL dealing with the achievements of pioneers in the industry and has arranged for an exhibit of historical apparatus for the present convention. Members are urged to donate apparatus of historical interest, which will be placed permanently on exhibition in a suitable depository.

Four new committees have been appointed, dealing with Projection Practice, Projection Theory, Projection Screens, and Sound. The Projection Practice Committee has set an example for other committees to follow by establishing regular bi-monthly meetings and its deliberations have resulted in recommendations for standard layouts for projection rooms, improved projector design, and remote control of volume.

The Projection Screens Committee is endeavoring to acquire sufficient data to permit a recommendation for a standard of screen brightness, and the Sound Committee is assembling information on ways of improving methods of sound recording and reproducing. Other committees in the process of formation will deal with laboratory practice and studio practice and it is proposed to appoint separate subcommittees on both the east and west coasts to deal with these problems.

It is through the committees that the Society can best serve the industry in the capacity of a coördinating and coöperating medium. Committee work can take the form of (*a*) reports on progress, (*b*) the formulation of standards, and (*c*) a discussion of new problems. It appears to be an open question as to whether or not committees should undertake to perform research work but when this is possible without entering into comparisons of competitive materials, it is very desirable and is to be encouraged.

The past six months have also been made conspicuous by the increased activity of the Society in collaborating with other organizations and societies having interests related to our own. Our Society has acquired membership in the American Standards Association, which has recognized the various standards adopted by the Society, and also in the National Fire Protection Association, which has invited the Society to collaborate with regard to safety measures in the handling of nitrocellulose film. Contacts have been made with the Institute of Architects with a view to collaborating in the design of theaters, particularly with regard to projection and acoustical requirements.

The Society will be officially represented at the 1931 International Congress of Photography in Dresden and arrangements for the exchange of technical manuscripts have been made with the Deutsche Kinotechnische Gesellschaft, which has conferred Honorary Membership upon the Presidency of our Society. The Society was also represented officially at the Inter-Society Council on Color Specifications, sponsored by the Optical Society of America.

In conclusion, I wish to thank the secretary and treasurer, the various committee chairmen, the members of the Board who have given unsparingly of their time and energy, and all those who have labored in the interests of the Society.

J. I. CRABTREE, *President*

COMMITTEE ACTIVITIES

REPORT OF THE PROJECTION PRACTICE COMMITTEE*

SUBCOMMITTEE ON PROJECTION ROOM PLANNING

The following recommendations have been adopted, after an exhaustive study, by the entire committee and are submitted for adoption as standards. In following them the local code should in all cases be consulted for deviations from these standards. It is the aim of the Committee to bring them before the various agencies for revision and adoption. Three layouts have been adopted, marked A, B, and C, which were planned for flexibility, simplified construction, ease of operation, *etc.*, to be selected according to the size of theater and type of operation. The key to the symbols used on the plans is shown in Fig. 1, and the three plans are shown in Figs. 2, 3, and 4.

(1) *Projector Spacing.*—The distance between projectors shall be not less than $4^1/_2$ feet nor more than 5 feet, measured between lens centers; for projection distances less than 100 feet, the spacing shall be 4 feet. When two projectors are used, they shall be equally spaced on either side of the center line of the auditorium. When three projectors are used, the center projector shall be placed on the center line of the auditorium.

(2) *Observation Ports.*—Observation ports shall be 12 inches wide and 14 inches high and the distance from the floor to the bottom of the openings shall be 48 inches. The bottom of the opening shall be splayed 15 degrees downward. In cases where the thickness of the projection room wall exceeds 12 inches, each side shall be splayed 15 degrees.

(3) *Projector Ports.*—Projector ports shall be 10 inches wide and 12 inches high (see Fig. 5). The bottom and sides of the openings shall be splayed in the same manner as observation ports. The

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

distance from the floor to the bottom of the openings shall be in accordance with the table of projection angles as given in the accompanying plans for the layout of the projection room.

(4) *Other Openings.*—All other openings, such as those intended for effect projectors, double dissolvers or single spot lamps shall be 24 inches wide and 34 inches high. The distance from the floor to the bottom of the openings shall be 26 inches when the angle of projection is not greater than 20 degrees. For projection angles greater than 20 degrees, one inch shall be deducted from this value for each degree in excess of 20. The minimum spacing allowed between these openings shall be as shown on the plans for the projection room layout. The placing of these openings to the right or left of the projectors shall be optional and according to conditions.

(5) *Dimensions of Projection Room.*—The projection room shall have a minimum height of 10 feet and a maximum of 12 feet. The minimum depth of the room shall be 12 feet. The length of the projection room shall be governed by the amount and type of equipment, as shown on the plans. Consideration should always be given for probable future needs.

(6) *Front Wall.*—In all cases, the inside surface of the front wall of the projection room shall be smooth and without structural projections. Care shall be exercised in locating the hanging rods and columns in the front wall so as not to interfere with the proper location of the various openings.

(7) *Conduits.*—These shall in all cases be concealed, and all boxes shall be of the flush-mounting type.

(8) *Projection Arc Conduit.*—The size of conduits for projection arcs shall be as indicated on the plans. These sizes anticipate the need for future increased capacity, and should be adhered to in order to provide space for pulling in larger wires as needed.

(9) *Conduit for Sound Equipment.*—Conduit for sound equipment shall conform with the type of sound equipment to be installed. The manufacturers of such equipment should be consulted with regard to the proper layout of the sound system before proceeding with the installation.

(10) *Projection Room Lighting.*—An individual ceiling fixture with canopy switch shall be installed for each piece of equipment, and shall be placed in line parallel to the front wall at a distance not less than 18 inches or more than 24 inches from the front wall. The outlet connected to the emergency lighting system shall be

located in the ceiling midway between the extreme ends of the projection room, and 4 feet from the back wall. Small projection rooms shall be equipped with one reel light and large projection rooms with 2 such lights conveniently located.

(11) *Ventilation.*—A separate exhaust system of ample capacity shall be provided for the projection room and other adjacent rooms provided for projection equipment. All projection arcs, and arcs of other equipment as required, shall be connected into the ducts of the exhaust system, which should contain a blower type exhaust fan. There should also be a gravity vent in the main projection room, rheostat room, generator room, and sound equipment room, leading directly through the roof. The minimum size shall be 12 by 18 inches, maximum size 18 by 24 inches. They shall also be equipped with swivel cowls. A supply of fresh air shall be brought into the projection room, preferably at the floor level and at the extreme ends of the room, and shall be baffled to prevent direct drafts. In cases where the theater is equipped with a refrigerating system, the projection room system should be connected into the main duct of this system. A fan shall be provided of sufficient capacity to remove all smoke and gas in case of fire, and this fan should be so connected to the port shutter controls that its full capacity will be automatically made available upon dropping of the shutters.

(12) *Extra Rooms.*—A separate room shall be provided solely for the rheostat equipment. This room shall be provided with ventilating means as previously set forth. An additional and separate room, properly ventilated, shall be provided for the sound equipment.

(13) *Toilet and Wash Room.*—Hot and cold water and other toilet facilities shall be installed and located convenient to the projection room. Suitable space shall also be provided for clothes lockers.

(14) *D-C. Supply for Arcs.*—Two generators or other sources of direct current shall be installed to insure continuous operation in case of breakdown.

(15) *Location of Arc Generators.*—Arc generators may be located in a room adjacent to the projection room, and the responsibility for their maintenance delegated to a projectionist. Where the generators are large, making it necessary to reënforce the structure carrying them, they may be placed in the basement, provided proper maintenance is assured. Where the generators are placed near the

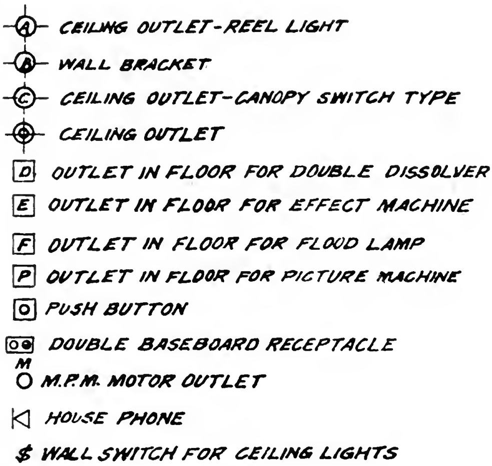
projection room, this room shall be sound-proofed and the foundation for the generator arranged to thoroughly eliminate the noise and vibration of the generator.

(16) *Projection Port Shutters.*—(See Fig. 5.) These shall be constructed of not less than 16 gauge iron guides built up of iron flats, 2 inches wide and $^1/_8$ inch thick, with spacers 1 inch wide and $^1/_4$ inch thick for the shutter to slide in. The shutter shall be made of not less than 10 gauge iron, provided with leather bumpers on sill at the bottom to take up the shock when the shutter drops. Each port shutter shall be connected to a master rod by a string and ring attached to a pin on a master rod. The master rod is to be fastened securely to the front wall, approximately 18 inches below the ceiling. It should be provided with a sufficient number of bearings properly aligned to assure smooth operation, connected through pulleys and fusible links located over each projector and capable of being controlled at the exit so that it may instantly be tripped. All large openings in addition to the above shall be provided with an individual approved counterweight (see Fig. 6) which will permit the shutters to be easily opened and shall be controlled by the master rod. All observation ports shall be provided wth metal guides to receive $^1/_4$-inch clear glass, this glass to be at an angle opposite to the projection angle and arranged to be easily removed for cleaning.

(17) *Projection Room Painting.*—A sufficient number of coats of paint shall be applied to assure a good coverage. Walls and doors shall be painted an olive green to the height of the door line. The walls above this line and the ceiling shall be painted buff. All painted surfaces shall be stippled to prevent reflections. All iron work on projection ports shall be covered with 2 coats of flat black paint. All other rooms shall be painted buff.

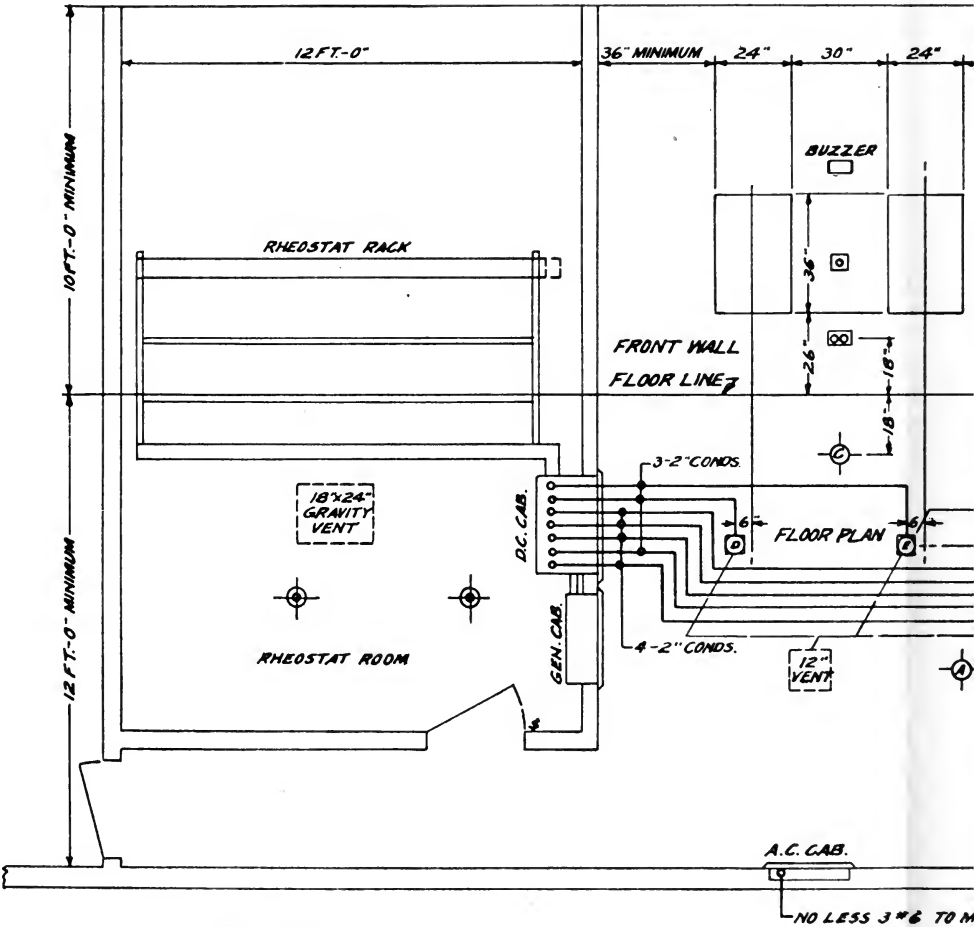
(18) *Projection Room Floor Covering.*—The floor of the projection room shall be covered with a good grade of "battleship" linoleum (brown or green) or rubber tile securely glued down. The floor covering should be laid before the equipment is installed. The floors of rooms adjacent to the projection room should be painted with a good grade of concrete paint.

(19) *Fire Extinguisher Equipment.*—The local fire department or safety commission should be consulted regarding the proper type, amount, and location of fire extinguishing equipment. In all cases there shall be adequate provision of such equipment.



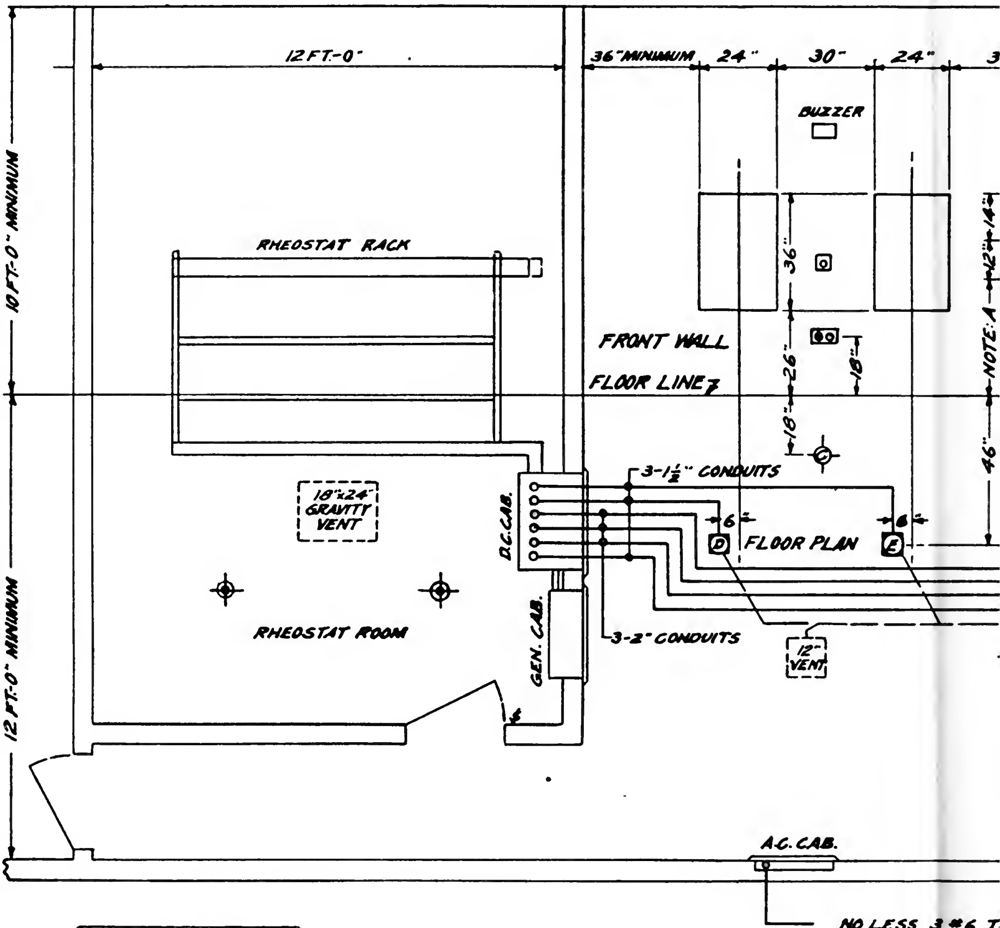
Wire Sizes		
Low Intensity	30 A.	No. 4
Reflector High Intensity	75 A.	No. 2
High Intensity	125 A.	No. 00
Super High Intensity	200 A.	200,000 C. M.

Fig. 1. Key of symbols for projection room layouts.



NOTE: A	
PROJ. ANGLE	HEIGHT
0° TO 10°	40"
11° TO 15°	36"
16° TO 22°	32"

ALL CONDUITS CONCEALED - ALL BOXES FLUSH
SPLAY BOTTOMS OF ALL FRONT WALL OPENINGS 15°



NOTE: A	
PROJ. ANGLE	HEIGHT
0° TO 10°	40"
11° TO 15°	36"
16° TO 22°	32"

ALL CONDUITS CONCEALED - ALL BOXES FLUSH
SPLAY BOTTOMS OF ALL FRONT WALL OPENINGS 15°

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(20) *Projection Room Construction.*—(*a*) The projection room shall be of fire-proof construction, and all walls exposed to the theater shall be of tile brick, gypsum, or any approved fire-resisting material. The walls of the projection room shall be not less than 6 inches thick and shall be covered inside and outside with a layer of plaster at least $^3/_4$ inch thick. The inside walls and ceiling of the projection room shall be coated with an approved sound absorbing plaster. Projector ports should be blocked down after the projector is set to as small an opening as possible.

(*b*) The ceiling shall be of plaster or concrete suspended on metal lath, and the floor slab should be not less than 4 inches thick, having a 2-inch cinder fill above, and a 2-inch cement finish above the cinder fill.

(*c*) The walls of rooms adjacent to the projection room shall be not less than 4 inches thick, plastered inside and outside. Two exits shall be provided, one at each end of the projection room, in addition to stairways for entering the projection room. Under no circumstances may ladders be used for the projection room entrances.

(*d*) The doors shall be of the approved metal type, swinging outwardly from the projection room, and shall be provided with door checks or other approved door-closing devices.

(21) *Heating.*—Proper provisions shall be made for heating the projection room. The same facilities used for heating the theater should be extended to the projection room.

SUBCOMMITTEE ON PROGRESS AND IMPROVEMENTS IN PROJECTOR DESIGN AND ACCESSORIES

This Subcommittee was formed for the purpose of analyzing certain difficulties in connection with motion picture projection and sound reproducing equipment, and to suggest remedies therefor. The difficulties brought to this Subcommittee's attention were as follows:

(1) inaccessibility of various parts of projectors;
(2) scratching of film while in transit through the projector;
(3) oil reaching the film during projection, due to leakage from various parts of the projector mechanism;
(4) difficulty of replacing mechanism when used in connection with sound reproducing equipment.

(1) *Inacessibility of Various Parts of the Projectors.*—This prob-

lem has been studied somewhat by the Subcommittee, and some progress has been made. The Committee hopes to present the solution of the problem in the near future.

(2) *Scratching of Film While in Transit through the Projector.*—

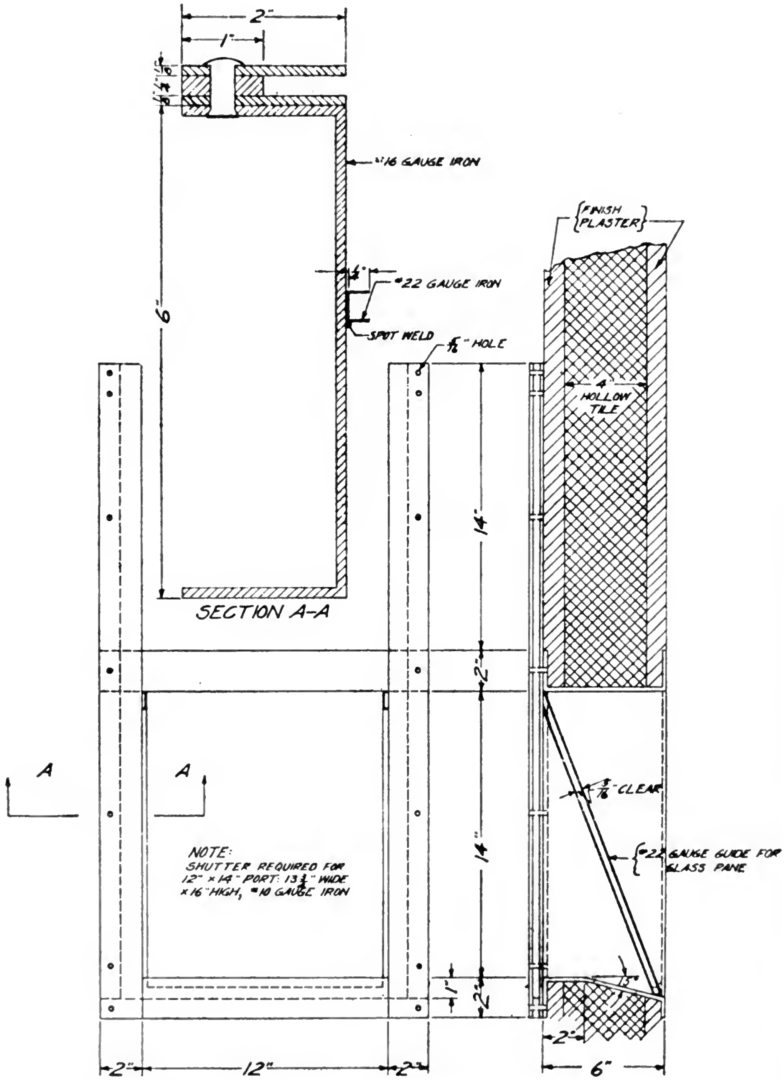

FIG. 5. Standard projection room port opening.

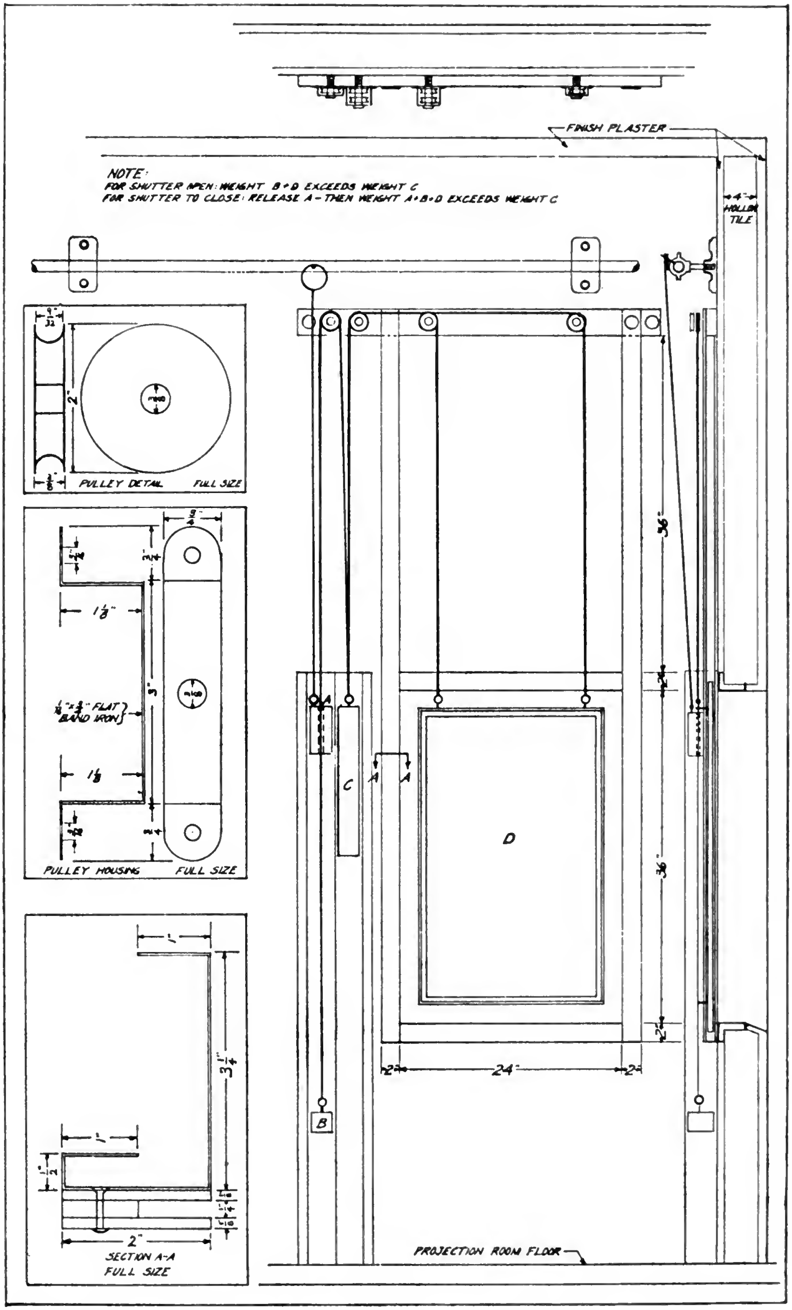

Fig. 6. Standard counterweight system for large size projection room port.

The suggestion was made that the tolerances existing between the magazine rollers be increased to such an extent that there is no possibility of film coming into contact with metal while passing through them. It was pointed out that as a fire prevention measure, the laboratories of the National Bureau of Fire Underwriters require definite dimensions maintained at these points. They allow sufficient leeway, however, so that if the film is not buckled, there is no possibility of its coming into contact with metal parts excepting at the sprocket holes. It was also pointed out that scratching of the film may occur when the projectionist allows the film actuating parts and film guides to become worn to such an extent that the clearance of a few thousandths of an inch is obliterated. It is obvious that these parts should be carefully watched and replaced when such wear occurs.

(3) *Oil Reaching Film during Projection, Due to Leakage from Various Parts of the Projector Mechanism.*—It was pointed out by the manufacturers of projectors that this difficulty was encountered only in the old types of equipment, and that improvements have been made for eliminating this. One of the worst offending assemblies which causes leakage of oil is the intermittent movement, which must normally be kept filled with oil to a certain level. Indicating sight gauges are placed in the oil boxes so that the projectionist may observe the height of the oil. In the old types of equipment, this sight glass was cemented into the casting. In time, the cement would disintegrate in places, allowing the oil to seep through. Also, in the old type movements, the shafts were designed without provision for carrying the oil back into the oil chamber when the bearings became slightly worn. These difficulties have been eliminated in the newer equipment, and the accompanying illustration shows how this has been accomplished. Section B, of Fig. 7, shows a view of the intermittent casing and at *A* are shown the new type oil sight glasses. Instead of cementing these glasses, threaded bosses have been provided, into which are first placed a washer, then the glass and another washer, and the entire assembly is tightened with a packing nut. Two such oil sights are provided and leakage at these points is entirely eliminated. The leakage of oil from other parts of the movement is prevented by felt washers under pressure as shown at *E* and *D* (Fig. 7). Oil is prevented from seeping through the bearing for the star wheel shaft *C* by a reverse groove cut in this shaft, which acts as a pump and carries oil seeping out of the inter-

mittent casing back into the case before it can reach the end of the bearing. These improvements can be assembled into existing projectors using this type of movement. It is only necessary that the movements be rebuilt in order to eliminate oil leakage from this source. The difficulty of oil leakage was also encountered in practically all the other shafts in the old types of projectors, but has

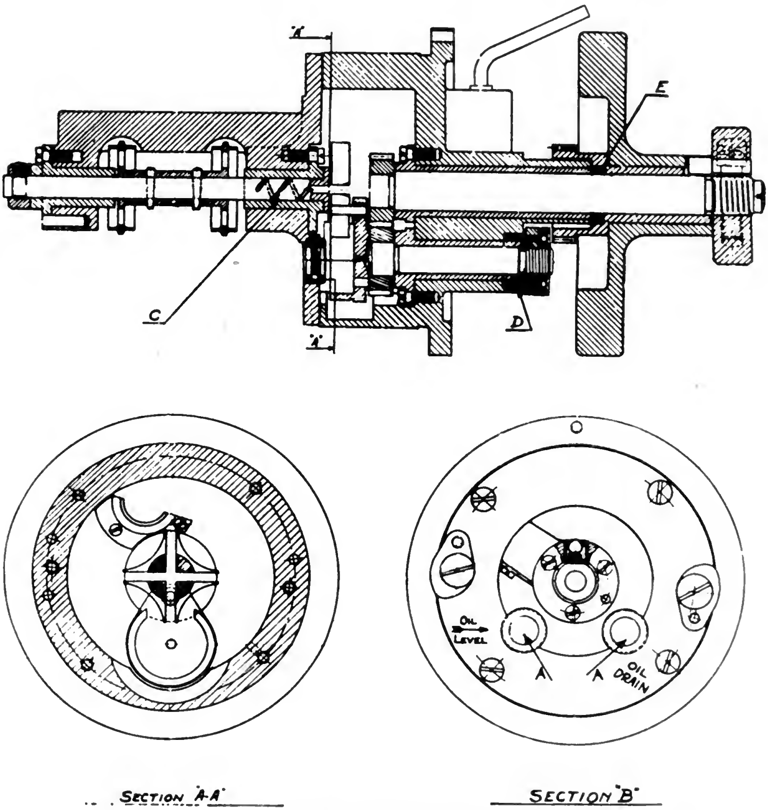

FIG. 7. Intermittent casing, showing location of oil sight glasses and methods of avoiding oil leakage.

been eliminated in the more modern equipment by cutting a reverse spiral curve in these shafts to carry the oil in the opposite direction to the side of the projection mechanism into which the film is threaded.

(4) *Difficulty of Replacing Mechanisms When Used in Connection with Sound Reproducing Equipment.*—This has been a very serious problem since the introduction of sound reproducing equipment

but it is mainly encountered in connection with what is known as the "D-Spec." attachment. This was the first attachment made, and consideration was not given at the time to the varying tolerances allowed by the manufacturers of the projector prior to the advent of sound film. It was not necessary to machine rough castings to which nothing was to be attached when projecting silent pictures,

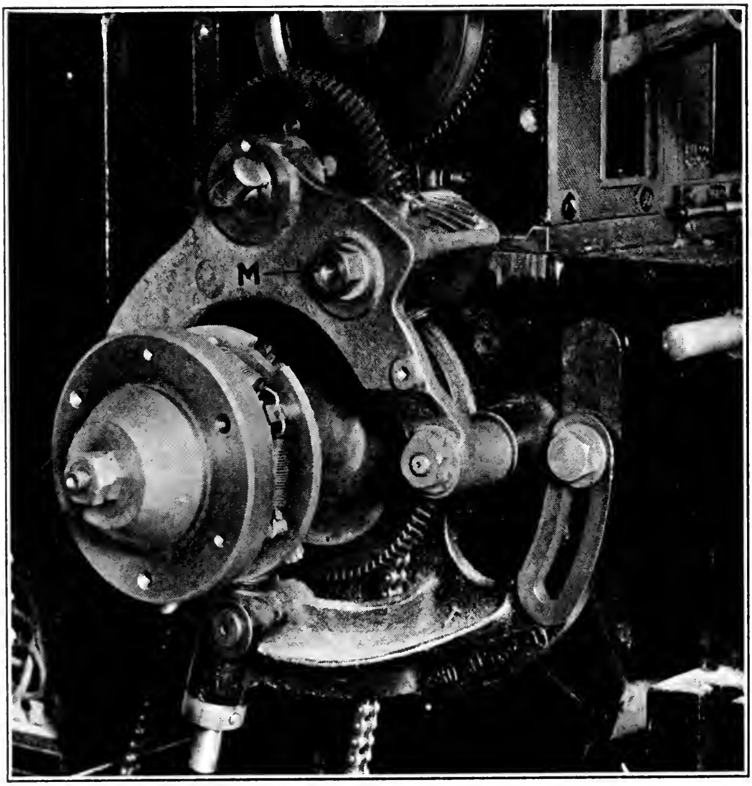

FIG. 8. New sound attachment for avoiding shimming.

but great difficulty was experienced when sound attachments were added to these unmachined surfaces. It became necessary to use shims varying from one-eighth of an inch to one-thousandth of an inch on the several corners of the mechanism in order to properly align the projector mechanism with the sound equipment drive.

Whenever a breakdown occurred during the running of a show,

several hours or more were required to adjust the mechanism Since the majority of theaters in this country are equipped with only 2 sound-equipped projectors, a theater in which such a breakdown occurred would be left with only one projector to run the show until the other projector had been repaired. This, in turn, made it impossible to give an up-to-date and smoothly running performance.

The problem of solving this difficulty was put up to the manufacturers of both sound equipment and projectors, and an attachment was developed which eliminates the necessity for shimming.

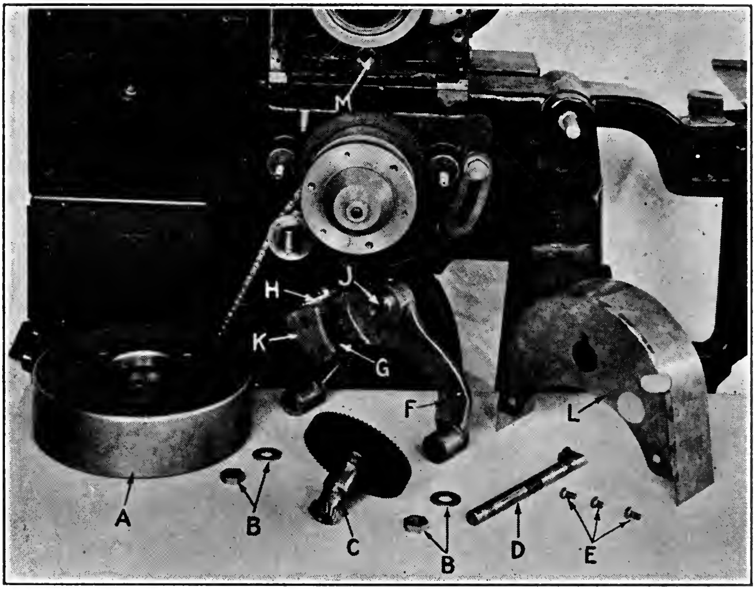

FIG. 9. New sound attachment dismantled.

This attachment is quite flexible and by its use the difficulty of replacing mechanisms on this old type of sound attachment was entirely surmounted, so much so that mechanisms may be readily changed within fifteen or twenty minutes.

Fig. 8 shows the new attachment It is only necessary to remove the gear retaining yoke from existing D-Spec. attachments and replace it by the new yoke and idler gears shown in the illustration. This yoke is self-centered on the driving spindle for the projector mechanism and it is only necessary to insert the spindle in the bearing

and push it into the hole provided in the mechanism to receive it. The yoke is then securely locked on the frame of the sound attachment and the bracket carrying the idler gears is then adjusted to eliminate lost motion between the gear teeth and the driving unit. The idler gear bracket is then securely locked in place by means of lock nut *M*.

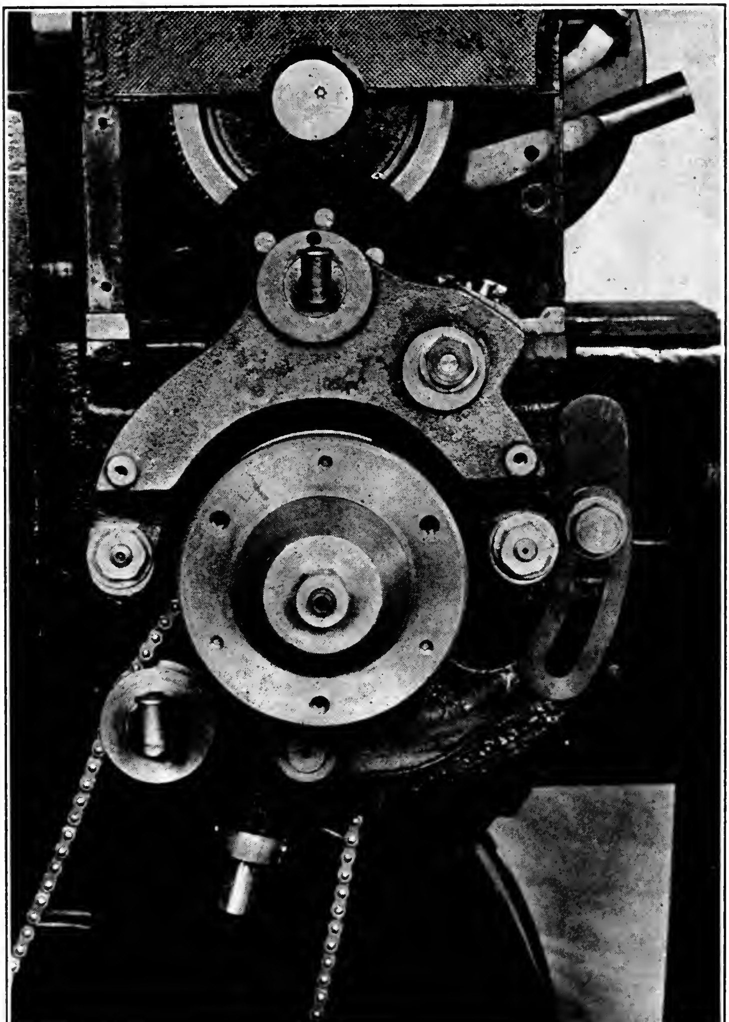

FIG. 10. Front view of the new sound attachment assembled on projector and sound unit without cover and flywheel.

Fig. 9 shows the assembly dismantled. At *A* is the flywheel which is always provided with the sound attachment; this is readily removed by taking out three screws. At *B* are the lock nut and washers for attaching the new yoke to the sound attachment; at *C* are the driving gears connecting the mechanism through the idler gears *G* and *H* to the main driving gear on the sound unit; at *D* is the spindle which slides into the hole *M* and upon which the assembly *C* revolves; at *E* are the three screws for attaching the protecting cover *L* after the unit is assembled; at *F* is the self-aligning yoke which carries the idler gear assembly; at *G* and *H* are the idler gears; at *J* is the adjustable bushing to take out end play in assembly *C;* and at *K* is the adjustable idler gear bracket.

Fig. 10 shows a front view of the attachment assembled to the projector and sound unit without the protecting cover and flywheel.

No shimming is required with this new attachment regardless of the age of the projector on which it is mounted, and it is felt by the Committee that this unit satisfactorily solves the problem of replacing mechanisms where the old type of sound attachment is used.

SUBCOMMITTEE ON MONITORING AND CONTROL OF SOUND IN THEATERS

In the report of the Projection and Sound Reproduction Committee, which was presented in abstract before the Society at Washington, and in full before the New York Section, June 12, 1930, there appeared a section on adjustment of volume levels and remote control. This report dealt principally with methods of controlling volume directly by an observer in the auditorium. As a matter of fact there are now devices on the market which permit such control. Whether the use of these devices has proved effective is not clear but the fact remains that there is a general urge to investigate fully the whole problem of volume control.

There are three distinct systems for providing volume control for theaters:

(1) the method most generally in use which, to be effective, requires an observer in the audience who signals the projectionist for volume change;

(2) the method described in the above report which provides actual control of volume by the observer in the audience;

(3) a method which attempts to give to the projectionist some means of knowing what volume of sound is present in the auditorium, from which means he can adjust the volume from the projection booth.

Before discussing the advantages and disadvantages of these three methods, we may observe:

(*a*) The present monitor horn functions reasonably well for the purposes for which it was intended, namely, (i) means of checking the sound system before the start of a show and (ii) maintaining a running check of the system during its operation.

(*b*) It seems evident that from a theoretical standpoint the best location in which to hear the results obtained in the auditorium is in the audience itself. An observer placed in the audience hears just what the audience hears, can take into account the audience's reaction, and note the effect of the changing number of people, which in many houses materially affects the sound absorption, *etc.*

SYSTEM (1)

System (1) is based on the theory that the actual volume control should be handled by the projectionist, and further, that the proper place to judge volume is in the auditorium itself. This system, therefore, has two most desirable features. The disadvantages are:

(*a*) A slight time lag between the giving of a signal by an observer in the audience and the volume adjustment made by the projectionist.

(*b*) The increased expense of having an observer in the audience.

(*c*) A chance of carelessness on the part of the observer or on the part of the projectionist which will result in poor operation.

(*d*) The arrangement being described anticipates a rehearsal before the opening of the show. With the new release print in vogue, the need of such a rehearsal is less since the change-over cues are automatically indicated.

To refute these objections it might be said of (*b*) that a first-class house can well afford such an observer (who would be absolutely essential to system (2) which is to be described below), and furthermore, that a small house which could not afford an observer could probably not afford additional monitoring equipment unless it were very cheap. Additional equipment requires maintenance and usually the cheaper the equipment the greater the maintenance.

Item (*c*) anticipates carelessness on the part of the personnel but no matter what system is employed carelessness results in a poor show.

Item (*d*) is included under carelessness because if the manager is alert a rehearsal should be demanded even if only for sound cues.

SYSTEM (2)

System (2) indicates actual control of volume by the observer in the audience. This system has the advantage of reducing time lag to a minimum and permits the control to be handled in the audience, which is the best position for such observations. The disadvantages are again, the additional expense in providing an observer and the absolute necessity that this observer must always be present, for if he is not, the entire method is not workable. It might further be observed that the man in the audience must have knowledge of the capabilities of the system itself, otherwise he may overload the amplifiers in attempting to override audience noise during periods of applause or laughter. The best arrangement of this system calls for remote control of the fader because if the audience control is simply an auxiliary to the fader in the projection room it produces additional loss in the amplifier system which may be disastrous if perchance the amplifier system gain is only sufficient to meet normal operating conditions. There is, furthermore, a tendency toward split responsibility, which is not ideal.

SYSTEM (3)

System (3) anticipates that the projectionist may have some means of knowing what is taking place in the auditorium, so that he may have entire control of volume adjustments. Any such system will obviously be more elaborate and costly than either of the other two systems described, and whether it will be more effective and usable is doubtful.

There are several methods proposed to accomplish system (3):

(*a*) One system provides a microphone, or several scattered microphones, connected to an amplifier and then to a loud speaker located in the projection room.

The advantages are claimed to be that with a microphone in the audience the sound from the horns can be picked up and the projectionist can then know what sound is being received in the auditorium. In other words, the projectionist's ear has in a sense been extended into the auditorium proper.

It must be remembered, however, that it will be necessary to calibrate very carefully the over-all gain of the amplifier system so that the sound in the projection room will definitely indicate whether the volume in the house is lower or higher than it should be. If anything goes wrong with the equipment so that the over-all gain is

changed, the results obtained in the monitor horn will not indicate the true condition. Furthermore, the microphone will not completely reflect the effect caused by the changing number in the audience. Any effect from noise in the projection room which now hampers good hearing with the present monitor would also apply even to a greater extent to the proposed system.

(*b*) A second method proposed makes use of a microphone or several scattered microphones in the auditorium connected through an amplifier into a volume indicator.

The advantage here would be that a visual indication is presented to the projectionist which would not in any way be affected by the noise in the projection room.

There are several disadvantages. To make the system effective there should be an optimum point of operation indicated on the meter of the volume indicator with maximum and minimum points shown, above or below which the sound should never be allowed to go. The difficulties in designing such a meter and accompanying circuit are extreme. Furthermore, noise picked up from the audience, such as laughter or applause, immediately indicates increased volume on the meter. In present-day projection rooms, which are fairly well sound-proofed, a projectionist might conceivably react in such cases by believing that the sound volume through the horns is too loud and, as a result, he may reduce the gain of the amplifier system when it really should be raised. Again, a very careful calibration would have to be made in order that the indicator would give a reading of true conditions. If any of the constants of the circuit should change, an incorrect indication would result, with corresponding improper sound volume in the house. Likewise in this case, as under item (*a*), the microphone will not definitely take into consideration changes in the number of persons in the audience.

(*c*) A third method has been suggested, using a headset instead of the loud speaker in the projection room. This has such obvious disadvantages from an operation standpoint that there is no need for discussion.

CONCLUSIONS

It is the opinion of the Committee, that:

(1) the proper and best place for observance of volume is in the auditorium among the audience;

(2) any manually operated volume control system requires

that the observer be trained to judge proper volume in the auditorium;

(3) there is not at the present time any mechanical or electrical device which will give to the projectionists any satisfactory means of judging volume;

(4) with the observer stationed in the auditorium it should be recognized that the responsibility of the projectionist in controlling volume is only to react to the observer's signals promptly and diligently;

(5) until some other means not now apparent are provided, the present system of volume control, as now installed in the majority of theaters, is the most satisfactory. This system provides signaling means for the use of an observer in the auditorium to inform the projectionist when to raise or lower volume and assumes a competent observer and painstaking projectionist, which are requisites for a good performance in any and all cases;

(6) it is of the utmost importance that the manager be made to realize that the responsibility for obtaining good sound reproduction is primarily his own responsibility. He must provide at all times a trained observer, whether it be himself or someone appointed for that purpose. He must educate himself to know whether the sound system is working properly and that the projectionists are responding to the signals of the observer;

(7) regardless of where the volume control mechanism is operated it would be advantageous that the projectionist be able to hear what is taking place in the auditorium. It is urged that efforts be continued to make such means possible.

SUBCOMMITTEE ON PROJECTION ROOM ROUTINE AND MAINTENANCE

(1) With the introduction of sound apparatus into the theaters, the responsibilities of the projectionist have been greatly increased. The theater owner's investment also has risen proportionately. It is to the mutual interest of both owner and projectionist that the fullest measure of value be extracted from each and every item of equipment (consistent, of course, with the quality of the performance, which must always be the first consideration).

(2) The Committee feels that a detailed account of each and every item of work performed by the projectionist will not be of much practical value as such details vary greatly with each in-

stallation and type of performance. The Committee, however, desires to outline a general system of routine which will illustrate the close attention required for the proper functioning of equipment and for the perfect presentation of sound film entertainment.

(3) A printed form should be provided for the projectionists' daily report. This form should include space for entering each film or other subject included in the performance, and blank columns for entering the starting time of each subject on every performance. It should include the names of the projectionists on duty, with the starting and finishing time opposite each name. Spaces for reports as to the condition of film, the condition of equipment, supplies needed, supplies received, irregularities and imperfections of performances should be provided, in addition to space for records of vacuum tubes put in service or removed and the number of hours of use at time of removal.

(4) This form may be made in duplicate, one being retained in the projection room and the other being sent to the manager.

(5) It is fully as important to retain a record of the projection room as it is with every other branch of the business. By keeping this daily record accurately, both manager and projectionist can readily determine conditions of equipment and supplies. In many cases they are thus able to eliminate waste.

(6) Projectionists should report each day, sufficiently in advance of the scheduled opening time of the performance, to make the necessary horn and other tests of projection and sound equipment; to ascertain if batteries are in proper condition; observe meter readings; check projectors for equal volume; remove from charge such batteries as are intended for immediate use at least one-half hour prior to such use; and observe condition of vacuum tubes.

(7) They should consult the schedule of performances, noting particularly any deviation from previous schedules; consult the bulletin board for information or cues left by other members of the projection staff; clean interior of lamps, arc contacts, reflectors, condensers, objective lenses, and fader; and examine arc leads for corrosion and test connections for tightness.

(8) They should lubricate the projectors and let them run for several minutes, noting whether they maintain an even speed of ninety feet per minute; stop projectors, clean film trap, sprockets, and fire rollers, and wipe excess oil from bearings to prevent accumulating oil on film; check projector mechanisms for proper tension

of take-up and film tension pads, for proper clearances of pad rollers, fire valves, and film trap, and for tightness of all set screws of connectors.

(9) They should then check the exciting lamps for discoloration, condition of filament, and proper line-up; see that the sound optical system is free of oil; rewind and examine film. If new program, rewind and examine film prior to first showing, observe if change-over marks are properly placed and if any defect, such as oil accumulations, scratches, buckling, strained or broken sprocket holes are apparent. Such defects should be reported immediately.

(10) Such parts of projection and sound equipment as do not require daily cleaning, lubricating, or inspecting should have a designated day of the week assigned for receiving such attention.

(11) The procedure as outlined above, if properly carried out, will guard against film damage. Faulty adjustments or worn parts will cause film damage—a cause of great loss to the industry. Film in bad condition, faulty adjustments, or worn mechanisms create possibilities of film fire, with its attendant danger and financial loss.

(12) In projecting picture or effect, the projectionist should strive to avoid imposing any distraction on the audience which would serve to destroy the illusion, such as flickering light, shaking or moving the projected image.

(13) He should be constantly alert in maintaining even illumination, sharp focus, smooth change-overs, and proper timing of opening and closing of curtain. He should fade the picture or effect on and off gradually, to convey an agreeable and smooth effect to the audience.

(14) He should be stationed constantly at the projector while it is in operation, and should be promptly responsive to signals for adjustment of volume.

(15) Where the control of the curtain is not directly handled from the projection room, a pre-arranged system of warning and closing signals should be used. Such signals usually consist of a two-buzz warning to the stage which is acknowledged on a return buzzer. A one-buzz signal is given at the moment of opening or closing of curtains or changing screen masking for various-sized pictures.

(16) Film should be examined after each run and checked for loose splices and scratches, and if oil has accumulated on the film, it should be wiped off and the projectors checked immediately to

eliminate further scratching. Projectors also should be wiped dry of oil after each reel and checked for accumulations of emulsion from the film.

(17) Where more than one projectionist is on duty and when a projector has been threaded, the arc trimmed and fully prepared for the showing of each succeeding reel, the projectionist completing this work should step to the running projector and relieve the other projectionist, to allow him to check each detail of threading and trimming, noting that the proper reel has been placed in the projector. This routine of checking should be firmly established in the projection room as it has been the means of discovering faulty threading and incorrect reels in time to make corrections and avoid interruptions or film damage without making such errors evident to the audience.

(18) A minimum supply of spare parts should be determined upon. An accurate record of necessary spare parts and supplies should be kept by projectionists, and when items are used which reduce the amount below the minimum figure, such items should be reported in the "Supplies Needed" column of the projectionists' daily report.

(19) When ordering parts, the correct technical designation and catalog number should be given wherever possible in order to avoid error in delivery. Catalogs of main items of equipment should be filed in the projection room for reference. Parts subject to breakage, such as gears, vacuum tubes, and connectors, should be distinguished from parts which are subject to gradual wear, and additional precautions should be taken to provide against emergencies arising through such breakage.

(20) To provide against accidental breakage of spare vacuum tubes, they should be stored in their individual boxes. Tubes, as well as other spare parts, should be further protected by being placed in a large metal cabinet containing shelves and equipped with a lock and key. This manner of storing will facilitate a rapid inventory checking of spare parts.

(21) Proper attention should be given by the projectionists to the matter of maintaining the proper level of electrolyte in batteries. The avoidance of over-charging or over-discharging will result in a full useful life of the storage batteries and, conversely, a lack of such attention will result in a very greatly shortened life and consequent waste and expense for replacement.

(22) Where a generator is used in place of batteries it will be necessary to inspect the commutator each day and wipe it off with cheesecloth moistened slightly with vaseline. If this practice is regularly followed, the commutator should remain in condition for perfect sound reproduction.

(23) Exhibitors should acknowledge the good work of the projectionists in maintaining the equipment in the best condition and should be willing to institute new ideas and install new appliances which contribute to better performance or increased efficiency.

In conclusion, it is the belief of the Committee that every owner, manager, and projectionist should take cognizance of the fact that the projectionist is in a position to contribute measurably to the advancement of the industry. Every projectionist should manifest a desire to conduct his work so that optimum screen results are efficiently secured.

Systematizing the routine work in the projection room is highly important, for it is only by the orderly arrangement of the many complex details that:

(1) thorough inspection, servicing, and checking of equipment can be made;
(2) equitable working arrangements, discipline, and harmonious coöperation between projectionists can be had;
(3) efficient results from projection and sound apparatus obtained;
(4) smoothly conducted performances secured.

PROJECTION PRACTICE COMMITTEE

HARRY RUBIN, *Chairman*

SUBCOMMITTEES

PROJECTION ROOM PLANNING AND LAYOUT

J. H. GOLDBERG, *Chairman*
J. J. HOPKINS
L. ISAAC
R. MIEHLING
L. M. TOWNSEND

PROGRESS AND IMPROVEMENT IN PROJECTOR DESIGN AND ACCESSORIES

H. GRIFFIN, *Chairman*
S. GLAUBER
J. J. HOPKINS
L. ISAAC

MONITORING AND CONTROL OF SOUND IN THEATERS

H. B. SANTEE, *Chairman*
L. ISAAC
R. MIEHLING
F. H. RICHARDSON
M. RUBEN
L. TOWNSEND

PROJECTION ROOM ROUTINE AND MAINTENANCE

J. J. HOPKINS, *Chairman*
L. ISAAC
M. RUBEN
R. H. MCCULLOUGH
S. GLAUBER

MEMBERS OF COMMITTEE AT LARGE

T. C. BARROWS
G. C. EDWARDS
C. GREENE
R. H. MCCULLOUGH
P. A. MCGUIRE

DISCUSSION

MR. LINTON: I take this opportunity to extend my thanks to the Committee for the completeness and magnitude of the report. Projection practice varies in different types of theaters and with the kind of program put on. We have little control over this, and, for that reason, I am sure that this report will be of great interest to all projectionists.

PRESIDENT CRABTREE: What is the objection to wearing one earphone for judging the volume?

MR. GRIFFIN: There are so many extraneous noises that it is impossible to obtain satisfactory results with an earphone.

MR. C. GREENE: Several years ago I had the opportunity of examining the Mechau projectors which were at the Capitol Theater and when spinning them by hand I was particularly struck with the ease with which they turned and with the silence of their operation. A non-intermittent projector that would run as silently as that one did would be a great boon to a sound projection room. A pneumatic rubber earphone, sold for years by office supply houses, originally designed for the Bell Telephone receiver, will fit the majority of standard double head sets. It fits snugly at the side of the head around the ear and leaves the entire ear free and normal—not under pressure—and seals out a surprisingly large amount of extraneous noise.

MR. GRIFFIN: The occasional use of earphones involves no difficulty, but I do not believe any projectionist would like to wear them throughout the entire day. A type of headset which would exclude extraneous noise would also make it impossible for the projectionists to communicate with each other. The Committee feels that the desirability of using headphones is very doubtful.

MR. GREENE (communicated): Naturally, I do not expect headphones to be used continuously. However, I wear my cushioned set at the opening of each performance and entirely through each rehearsal with no discomfort.

PRESIDENT CRABTREE: Cannot a horn or baffle be placed close to the projectionist as he stands at his machine? By placing his ear close to the horn he may be able to obtain a measure of the volume.

MR. SANTEE: The main difficulty with the headset is the nuisance of the

cord attached to it and the danger of its becoming entangled in the moving machinery. There is already a horn connected to the output of the amplifier, which does not give the volume obtained in the auditorium but a measure of the volume coming from the system itself. I assume you refer to a horn connected to a microphone in the auditorium. It is very difficult to calibrate a system of that kind, as pointed out in the report. A variable quantity, in the form of an amplifier, is between the microphone and the loud speaker. The substitution of a tube of different characteristics would destroy a calibration and make it impossible to judge correctly the volume in the auditorium.

MR. HARCUS: It is the object of the studios to send out pictures which will not require cueing during the running of the show. This is being accomplished quite successfully by most producers, desired changes of volume being recorded into the sound track so that with uniform house conditions the show will run on one fader step. If the two projection machines are balanced for volume and quality, and the manager calls for changes of volume as the house fills and empties, ordinarily all the essential showmanship will be properly cared for. There are a few exceptions to this at the present time, such as in musical shows where songs should be played up a step or two above "normal," and in pictures where the effect of some spectacular scene is enhanced by momentarily raising the volume several steps.

MR. SANTEE: That is covered in the Report of the Sound Committee.

REPORT OF THE SOUND COMMITTEE*

The Sound Committee, in preparing this report, has confined itself mainly to a consideration of the status of present-day practices in sound recording and reproducing. Some study has also been given to the possibilities of standardization as well as to those items which might well be investigated further.

Where a practice has proved itself worthy of usage it is the plan of the Committee to recommend it for standardization to the Standards Committee of the Society. It is recognized that in an art so comparatively young as sound recording and reproducing, care must be taken against premature attempts at standardization. The progress of development is so rapid and the technic of recording and reproduction is undergoing adjustment so quickly that premature attempts at standardization might prove a hindrance rather than a help. On the other hand, the moment any phase of the art becomes stabilized, it should be presented at once as a matter worthy of standardization throughout the industry.

In this report the Committee intends to show a cross-sectional view of the newer and more important phases of sound recording

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

and reproducing. It is not intended that the material presented here shall encroach upon the activities of the Progress Committee although there may unavoidably be some slight duplication.

Neither the Committee nor the Society now has facilities to carry on investigations, but it can recommend what is of importance for further progress in the art. The Committee, therefore, feels it may be of considerable service in presenting to the Society and to the industry matters on which work should be done. Some of the items which have been suggested to the Committee as worthy of consideration have already received sufficient study to permit the formation of definite recommendations. In these cases, arguments for and against are presented and the Committee's conclusions submitted.

Part I

STATUS REPORT

Directional Sound Detectors.—A directional sound detector comprises a device in which the efficiency of response is a function of the angle between the direction of incident sound and a reference axis in the system which coincides with the direction from which it is desired to receive the sound.

In general, there are two principles used in directional sound detectors, one amplifies the sounds desired by concentrating them and the other avoids or suppresses the unwanted sounds. Horn and reflector types employ both principles. The ribbon microphone and absorptive baffle make use of only the second.

Horns.—Horns have been long used in conjunction with various types of sound reception apparatus, but have not been used for high-quality pick-up due to the difficulty of obtaining a good frequency characteristic in spite of the apparent efficiency of this type of unit.

Reflectors.—The use of reflectors for the reception and focusing of sound is well known. In order to receive sound pressure variations over a wide frequency range, it is necessary to use a reflector having large dimensions. Within practical limits of size, a reflector is likely to have a characteristic which will be better at the high end of the frequency scale than at the low end, although compensation for this effect can be applied.

Combination of Horn and Reflector.—It is possible to combine the horn and reflector principles in a device which has a fairly good resultant frequency response. The directional properties, however,

as limited by the design of a horn and a reflector, may not be uniform with frequency.

The directional characteristics of these devices have been found useful in eliminating undesired sounds and noises, particularly where the sound which it is desired to pick up is weak. The effectiveness has been greater for outdoor work where there is no reflected sound than for use in studios where reverberation is encountered.

Ribbon Microphone.—A properly designed ribbon microphone may be made very directional. Its directional characteristic is practically independent of frequency because of its dimensions, and, by virtue of its directional effect, increases the distance from which acceptable sound may be picked up, in spite of the fact that it receives a relatively small amount of energy due to its size. It is also particularly effective in reducing unwanted sounds, such as camera noises and the like.

Absorptive Baffle.—It has been found possible to design an absorptive baffle for a microphone in such a way that any sound coming from a direction not included in the throat angle of this absorptive structure will reach the diaphragm at a very much reduced intensity. This structure, while fairly large in dimensions in order to obtain the necessary absorption, is not dependent entirely upon the wavelength of the lowest frequency for its minimum dimension since the wave front remains practically undisturbed. This arrangement, of course, is no more efficient than the microphone would be without the absorptive device but its sharp selectivity of the direction from which it effectively receives sound makes it appear promising.

CAMERA SILENCING DEVICES

Silencing of cameras became necessary with the advent of talking pictures. While the ideal method would be to use a silent camera, until such perfection is attained, it is necessary to place the existing cameras in some form of silencing box. This, in the first place, took the form of a camera booth large enough to house one or more cameras and the cameramen. Being extremely cumbersome and heavy, it was in some cases very difficult to place on a set and of necessity soon gave way to handier methods.

During this preliminary stage, much thought and work went into the methods of camera maintenance which resulted in their being brought to a higher state of mechanical perfection than had

ever before been attempted in the industry. It was also found that the commonly used means of interconnecting the camera and the camera drive motor by a flexible shaft was a great source of noise. This camera drive was a development of talking picture equipment which the weight of the early motors made necessary, as it was not practical to hang much weight on the camera structure.

At this period each studio investigated camera silencing in its own way. By a process of experimentation and elimination, the present-day devices were evolved. They are by no means ideal and are being continually changed and improved. The generally accepted opinion is, of course, that the ultimate solution of this problem will depend on the development of a silent camera which it will not be necessary to enclose.

In camera booths, the natural development was along the lines adopted by most studios (with a few exceptions), that is, an individual camera enclosing box which, in its early stages, was simply a wooden framework covered with various sound insulating materials. This did not silence the camera sufficiently to permit its use within fifteen or twenty feet of a microphone and it was soon replaced by more efficient designs. It is unnecessary to follow the various stages of this development, but from a survey of the present-day equipment it is easy to see that it is simply an elaboration of this silencing box.

The new camera silencing devices became known as "blimps" or "bungalows." In the majority of cases the bungalow was made to contain the drive motor as well as the camera. Some of the studios adopted a form of drive motor which was mounted directly on the camera; others retained the flexible shaft but enclosed it inside the bungalow. One or two of the studios made separate bungalows for the motor and the camera, and covered the flexible shaft with heavy layers of sound insulating material.

The Fox Movietone Studios adopted as standard a camera bag composed of rubberized cloth, kapoc floss, and other soft insulating materials, fastened by means of zippers and snaps. The lens and finder protrude through the bag.

With the adoption of the heavy bungalow covered camera, a very much stronger and more rigid camera-tripod became necessary. The bungalows used by Warner Brothers and United Artists are light enough to mount on the standard tripod. Most of the other studios adopted either a tripod which was developed by Metro-

Goldwyn-Mayer in collaboration with Pathé, or else an adaptation of this, used in conjunction with a standard tripod for rigidity.

The Academy of Motion Picture Arts and Sciences, under date of May 14, 1930, published through their Technical Digest Service, Report No. 3 of the Producers-Technicians Committee relating to camera silencing. This report gives in detail a complete résumé of all such devices in use at that time. It includes information on the insulating value in decibels, the methods of construction, materials used, and the distance that a microphone can be used from the camera.

NOISELESS RECORDING METHODS

The noiseless method of recording on film, announced at the end of 1930, appears to be receiving general acceptance throughout the industry. RCA Photophone has described two methods of effecting noiseless recording on variable width track. One of these displaces the zero line on the track in such a manner that the clear portion is only just wide enough to carry the modulation. This is subject to the disadvantage that weaving in the projector may cut off some of the weaker sounds. The second method uses a movable shutter during the recording which causes the clear part of the sound track to become blackened in those portions which are not employed to carry the modulation.

The Western Electric Company has announced a noiseless recording system which is applied to their variable density method. The density of the sound track is increased during the intervals in which the sound volume is low, and is decreased according to the envelope of the sound currents in such a manner that the film is always just able to accommodate the required modulation.

The Fox organization has devised a means for flashing lamp variable density recording, in which the intensity of the lamp is reduced during the intervals of low sound amplitude, the intensity being altered during the process of recording.

A number of independent makers of sound equipment, most of whom are using the flashing lamp, have announced attachments to their equipment which produce essentially similar effects.

The reduction of noise is accomplished during the actual recording by an attachment to the recording system, and, in general, involves no change in recording or processing technic. The amount of noise reduction which is being employed in most studios at the present time is of the order of 10 db.

SET AND STUDIO ACOUSTICS—THEATER ACOUSTICS

Extensive investigations have been made by many interested in the factors concerned in set and studio acoustics and theater acoustics. In some cases these studies have been made with recently developed instruments, permitting more accurate results than those previously obtained by aural methods. Several factors have been discovered by such means, some of which have contributed to the development of a more general formula for the computation of the time of reverberation. The application of this formula, which has been published by Dr. C. F. Eyring, of the Bell Telephone Laboratories, is of particular value in set and studio work, where average absorption coefficients are comparatively high. Important studies of the effect of relative humidity on sound absorption are being made.

The necessity for consideration of the reverberation existing throughout the frequency spectrum is now well appreciated. Whereas many enclosures had in the past been acoustically treated, giving consideration only to the reverberation at 512 cycles, experience in many of these cases indicates the necessity for obtaining suitable balance between the reverberation at the low and high ends of the frequency spectrum relative to that in the central portions of the range. It is becoming the practice to adjust theaters and recording studios to have times of reverberation throughout the frequency spectrum such as will give definite rates of decay for sounds of equal loudness. With the application of suitable accurate instruments for the measurement of reverberation times, studies have been made of the relative effects of connected volumes, which have an important bearing on complex auditoriums, as well as on recording sets on large stages. Further study, by instrumental means, has indicated the effect of direct reflections to be of importance and requiring consideration in the design of auditoriums, in addition to the consideration given the reverberation time.

The importance of maintaining a very low noise level has been extended to cover not only the studio, but the theater. This has become more necessary with the development of recording methods insuring a lower background level in the sound picture. Attention must be given to the transmission of noise from the projection room into the theater, from the ventilating systems, from sources external to the auditorium, and to miscellaneous noise sources within the auditorium.

More information is available upon the acoustic power required

to provide satisfactory sound volume in an auditorium. It is, therefore, possible to predict more accurately what effect the introduction of absorbing material into an auditorium will have upon the sound volume and, where necessary, upon the electrical requirements of the system.

Many improvements have been noted in existing commercial materials and a large number of new materials suitable for studio and theater use have been developed and introduced in the past year. This has considerably widened the field for obtaining materials having the desired acoustic characteristics for the particular application and which will be more readily acceptable from the standpoints of architectural appearance, fire hazard, and cost.

PRESERVATION OF SOUND PRINTS

The Committee has been fortunate in receiving from a firm prominent in the film industry the results of tests, conducted over a period of two years, of processes which purport to preserve motion picture film. The method used in these tests was to prepare loops of film, half of which were processed and half unprocessed, both sections being taken from the same reel or roll. These loops were projected 300 times, with examination at 100, 200, and 300 runnings, on a specially prepared projection machine, which caused as little wear as possible.

The processes tested were such as lacquer, surface hardening, whole surface waxing, chemical impregnation, liquid edge waxing, *etc.*

The noticeable effect of the processes investigated was that the film became seasoned more quickly, so that during the first few times of projection, the emulsion did not collect on the shoes and tracks of the projection machine as is often the case with green emulsion.

There was also indication from this set of tests that liquid edge waxing provides comparable protection. Once past this initial period, however, it was not evident that the processes provided any material improvement in giving greater lasting qualities to the film.

TALKING MOTION PICTURE EQUIPMENT FOR HOME USE

In recent years several talking motion picture equipments have been developed and offered for sale for home use. Practically all of these equipments use a 16 mm. projector with either a flexible shaft or geared connection to a synchronous turntable for disk repro-

duction of sound. All the devices examined, except one, project 24 pictures per second and employ a turntable driven at $33^1/_3$ rpm. This one exception projects 16 pictures per second and the projector and turntable are driven by electrically interlocked motors. In order to maintain synchronism with the $33^1/_3$ rpm. turntable, every third frame is removed in printing from the negative to the positive.

At the present time 16 mm. films synchronized with sound are difficult to obtain and are expensive. If an extended library of films were available, it is probable that a larger demand would appear for home talking movies. To date, the supply of films is extremely limited and these films are available only in the larger centers, requiring personal application to obtain them and personal return. This mitigates against very extended use of these films and is a serious detriment toward obtaining a large market for the reproducing equipment in the home.

TALKING MOTION PICTURE EQUIPMENT FOR NON-THEATRICAL USES

Considerable demand is apparent for talking motion picture equipment for non-theatrical uses, this equipment to be used either for advertising purposes, instruction work, in schools, churches, *etc.* Equipment for this purpose is built by all the leading talking motion picture apparatus manufacturers. The trend seems to be toward a 35 mm. film with sound on the film, although some equipment has been built with the idea of using 16 mm. film and a synchronized disk, which permits a picture of sufficient size and brilliance of illumination for small audiences. Libraries are being developed which will undoubtedly stimulate the exploitation of such equipment.

SOUND EQUIPMENT IN THEATERS

On January 1, 1931, there were reported to be in the United States 13,515 theaters equipped for sound reproduction and 8209 theaters unequipped. It might, therefore, appear that during the period of sound equipment installations only about 63 per cent were completed. Many of the theaters now running silent, however, are unprofitable houses which may never be able to afford sound equipment. With the decreasing number of silent picture releases, these theaters may be forced to close. It follows, then, that the installation period is well over 63 per cent completed. Perhaps 80 per cent would not be too high a figure.

It may be considered that the industry is passing out of the in-

stallation period and is now entering a period of stability in operation and of refinement. The novelty value of sound has passed with every indication that sound has become as necessary a factor in the theater as is the picture on the screen.

The first problem of theater projection is obviously to keep a picture on the screen and to maintain sound from the horns. It so happens that statistics from Electrical Research Products, Inc., are available, which show the ratio of emergency calls to theater installations in the United States over a period of time. In December, 1928, with roughly a thousand theaters equipped, the ratio of emergency calls per week to theaters in service was about 0.185. In December, 1929, with 3300 theaters equipped, the ratio had fallen to about 0.05. In December, 1930, when nearly 5000 theaters were equipped, the ratio was as low as 0.022. This decrease in emergency calls is caused by improvements in design and manufacture, and to proper and continued maintenance of the equipment. It is logical to believe that the operating troubles experienced with other reputable systems follow somewhat the same general course. It is consequently obvious that the first requirement of sound projection, namely, consistent and reliable operation, has been achieved. The quality of sound now focuses our attention.

Poor theater acoustics constitutes one of the most serious causes of poor sound reproduction in theaters. Acoustic analyses have been made in a large number of theaters and corrections of the conditions have been made in some cases. It often happens that the theaters less able financially to make the correction need it most. It has been proved in so many cases that improved acoustic conditions result in increased box-office returns that the expense of the change has been thoroughly justified. It is believed and hoped that more theaters can avail themselves of this improved condition not only for their own salvation but to give to the public all the benefits of the improved products which could not otherwise be realized.

There has probably been a healthy although unconscious competition between the studio and the theater in striving toward higher quality. Such improvements as better reproducers for disk records, finer optical systems, and smoother mechanical features for film reproduction, along with other general advances applicable to both methods, have raised the standards of the theater equipment to the point where they are capable of handling good quality recordings.

Improved technic in the studios, resulting from such factors as study of stage and set acoustics, microphone placement, better knowledge of re-recording methods, and more exact control of film processing, have made it possible for the studios to show a tremendous improvement in the quality of the recorded product.

The gradual extension of the frequency range has been a material contribution to this improved quality but efforts toward a greater range should be and are being continued.

Part II

ITEMS FOR FURTHER INVESTIGATION

PREFERRED SOUND TRACK SIZE AND LOCATION

The considerations which dictate the preferred sound track size and location are twofold—first, engineering, and, second, economic. For the present the second of these dominates. Engineering considerations tend to favor an increase in sound track width over the present track, although such an increase cannot be carried on indefinitely without encountering further engineering difficulties.

A number of locations for the sound track differing from the present have been proposed. The majority of these offer little to be gained from an engineering standpoint. Their effect is mainly to permit a change in the present picture size, and the principal difficulty standing in the way is an economic one. Until it has been possible to make a further engineering study of this problem, it would appear to be undesirable to disturb the producers' and theater owners' efforts to stabilize their economic positions by the introduction of equipment necessary to effect a relatively slight engineering or artistic improvement.

SOUND FROM SEPARATE FILM

At the time when sound recording and reproducing was just getting a start, the need for double film was felt rather strongly. Some difficulty was experienced in the proper processing of both sound and picture on the same film, and, in addition, the theater reproduction apparatus was less effective than it is today. At that time the industry was often able to obtain better than normal results by using the double film.

At present the situation is quite different. Theater reproduction apparatus has been greatly improved, and, moreover, a large part of the available theaters have been provided with sound ap-

paratus at considerable cost. To supersede this apparatus or to modify it in any way would represent a substantial increase in cost to the theater and would present an economic problem which should not even be proposed unless substantial advantages are to be derived from the change.

Separate sound film installations would permit:

(1) control of sound film independent of the picture;
(2) separate handling of the release print in processing;
(3) wider sound track;
(4) higher running speed for sound track.

There are no data existing to show that these improvements warrant an expensive change. In the first place, it is no longer considered a serious handicap to the sound record that in variable density records a negative development must be accommodated to the processing of the composite print. By proper choice of conditions, satisfactory results can be obtained differing only in volume from what might be obtained with the separate sound film. Noise reduction technic applied to the composite sound record is adequate for practical theater requirements.

Secondly, studio and laboratory technic has found practical solutions of most of the problems of development of picture and sound records on the same film, in positive form. This did not always seem feasible, but present results indicate no particular handicap. As a matter of fact, the positive control enforced by sound requirements has produced a general improvement in average picture print quality in many cases.

Somewhat the same reasoning applies to the wide sound track. With the track twice as wide as at present, an improvement of the order of three db. in signal-to-noise ratio should be obtained, with no change in quality. This improvement is scarcely sufficient to justify a large change in theater apparatus, in the light of noise reduction studies which are at present under way.

The case of high running speed for the sound track has advantages since the greater the speed of the track the greater the ease of recording high frequencies. There should certainly be no difficulty, however, in recording frequencies up to 6000 or 7000 cycles on existing film stock running at the present standard speed. The present recording and reproducing equipment, at least with modifications and improvements which will be made as the art progresses, should be capable of recording and reproducing this frequency

range. It would, therefore, seem wise to exert efforts to obtain good, clear reproduction with present facilities rather than to introduce additional means for extended range at this time. Ultimately the state of the art may warrant the recording and reproduction of very high frequencies in the audible range but it is not believed that the time is opportune to consider costly changes toward this until full advantage is taken of present equipment.

An important economic phase of the handling of film is the mechanism of release through the exchanges. Handling and shipping problems are such that the extra cost and complication of handling a separate medium for sound is almost prohibitive. Moreover, the problem of maintaining synchronism must be admitted. No numbering system, however complete, can be as satisfactory in this respect as to have the picture and sound records unalterably tied together on the same film. Even at present, the producers annually furnish thousands of feet of short replacements to take care of inadvertent or deliberate changes of a print in the exchange or theater to accommodate a particular situation. It has never been possible, thus far, to prevent such changes being made. Obviously, it would be very much harder to handle this phase of the problem on a double medium basis.

In the light of this brief analysis, it is the Committee's definite recommendation that the Society should take a stand in favor of improvements known to be possible in the present standard composite picture and sound print.

VOLUME CONTROL IN RECORDING

In the recording of sound for audible pictures, the volume range of the sound record is defined on the upper side by the overload point for the sound track and the cutover point for the disk, and on the lower side by the masking effect of the inherent noises in the sound record, known as ground noise or surface noise. This volume range was originally in the neighborhood of 30 db. and there was little choice between film and disk. As pointed out elsewhere in this report, the adoption of noiseless recording systems has increased the volume range on the film record by approximately 10 db.

In order to obtain a satisfactory ratio between the sound and noise level it was the custom in the past to raise the level of the weaker passages and lower the level of the louder passages at the time the record was made and to furnish the theaters with cue sheets

directing the projectionists to lower or raise the sound level at these points by amounts specified in the cue sheet. In practice, this has not proved entirely successful, as the projectionist's attention has been so largely occupied by other matters that he has been unable to properly follow the instructions given in the cue sheet. It has been found practicable to record the sound on the film at the levels at which it is intended to be reproduced in the theater. The cue sheet is, therefore, being abandoned. Consideration is being given to marking on the beginning of each reel in appropriate fashion the relative levels at which the reels should be reproduced.

The Committee will give further consideration to this important problem but suggests at this time that the trend be continued toward recording the sound at the proper levels.

FILM DEVELOPMENT

During the past year, radical changes have taken place in film developing. Almost universally, the use of machines for release prints has become standard practice. The developing of picture and sound negatives by machine has become almost general, as the results of machine development have proved to be superior in obtaining uniformity and freedom from mechanical injury. A matter that requires further study is the composition and maintenance of the chemical bath.

Although information is available to permit the proper development of sound film, and devices for controlling and checking the methods are at hand, the full use of such facilities is not yet being made. A uniform and consistently good product can only be obtained by constantly employing such instruments as a means of checking the results.

M. C. BATSEL	N. M. LA PORTE	H. C. SILENT
P. H. EVANS	W. C. MILLER	R. V. TERRY
R. C. HUBBARD		S. K. WOLF

H. B. SANTEE, *Chairman*

ABSTRACTS

The New Copper Oxide Cell. M. Arndt. *Phot. Ind.*, **29**, Feb. 25, 1931, pp. 237–8. The photoelectric effect or flow of electrons from a metal exposed to light has found application in the potassium and caesium cells, such flow being accelerated by including a battery in the circuit. A certain amount of energy of the incident light is necessary to initiate the flow of electrons. It has been found that a metallic salt in contact with the metal requires a relatively low level of energy to start the flow of electrons. This has found practical application in the new copper oxide photoelectric cell which is described by the author. Further developments of this kind would seem to be of importance to the future of sound films. C. E. M.

New Debrie Sound Film Camera. *Phot. Ind.*, **29**, Feb. 25, 1931, pp. 238–40. The new models seem well designed to meet all the requirements of sound film exposure. The camera stand rides on three rubber tired wheels controlled by an ingenious steering mechanism. The stand is made entirely of metal with an aluminum base containing the motors, resistance, *etc.* At the rear is a small platform for the operator. The camera is enclosed in a sound-proof housing which is mounted in a yoke upon a pillar so that it can pivot in a vertical plane.

C. E. M.

Sound Recording Apparatus for Expeditions. H. Freese and H. Lichte. *Kinotechnik*, **13**, Feb. 5, 1931, pp. 44–7. The need for sound recording apparatus that can be transported to the field by rail, ship, porter train, *etc.*, and still give results equal to those obtained with the apparatus of the studio, has caused Klangfilm G. m. b. H. of Germany to construct equipment that is contained in a number of water-proof cases. When the equipment is operating on location, power is generated by a two-cycle, single cylinder gasoline engine located 200 meters from the scene of action. This drives a 220-volt direct current dynamo. A transformer is located 50 meters from the scene, arranged to supply 1000, 135, and 15 volts for the plates and filaments of the amplifier tubes, driving motors for the sound and picture cameras, *etc.* At this distance are located also the control panel, sound camera, and amplifier, housed in a tent. Telephones, power cables to the picture cameras, and cables for the microphones run thence to the scene. The apparatus described is intended for features or short pictures. Cheaper and simpler apparatus is used for news recording. M. W. S.

Motion Picture Education in Japan. Y. Mizuno. *Internat. Rev. Educational Cinemat.*, **3**, Jan., 1931, p. 5. The history of the movement is given. Japan produced 718 theatrical films in one year. About 2 per cent of the films produced are educational. About 30 cinemas in Tokyo hold a children's movie day periodically on Sunday. The All-Japan Association of Cine Education directs the use of educational films in Japan, in the schools, factories, and for the women through a women's society. Sub-standard film is in wide use in the schools. R. P. L.

The Film Collection of the Austrian Ministry of Education. G. A. Witt.

Internat. Rev. Educational Cinemat., **3**, Mar., 1931, p. 213. An archive for important educational, cultural, and historical films has been instituted in Vienna. Both standard and sub-standard films are lent out and even projectors and cameras. It is also a center for information on cultural films. R. P. L.

Cinema and Visual Fatigue. G. D. F. *Internat. Rev. Educational Cinemat.*, **3**, Jan. and Feb., 1931, pp. 53 and 165. Another installment of the report of the investigation. Programs for children ought not to last longer than 10 to 15 minutes without a rest period of several minutes. The cinema should be forbidden for children under 16 after a certain hour in the evening. Only 14.5 per cent out of 19,661 children complained of bodily fatigue. R. P. L.

Empty Seat Indicators. *Film Daily*, **55**, May 31, 1931, p. 8. A system has been developed which makes it possible for the management of a theater to know at all times the seating of the house. By its means, the exact number of seats available in every section may be transmitted to the lobby of foyer quickly and accurately, resulting in the seating of waiting patrons immediately as seats become available. The system is said to consist of a number of dial sending stations located in various aisles, and a receiving station in the main lobby. By operating the dial at the sending stations, the ushers in any aisle may signal the number and location of the seats available. C. H. S.

New Continuous Projector. *Film Daily*, **55**, May 14, 1931, p. 64. A film projector called the "Kinisophote," operated on a continuous principle, has been invented and successfully demonstrated in Madrid, Spain. The machine runs continuously at a constant speed and the screen receives a constant amount of light, thus doing away with flicker. This projector permits the use of very thin (cellophane) film, which is driven by a single claw as only one side of the film is perforated. The sound track is placed in a 5-mm. space along one side, so that the section for pictures retains its normal one inch width. The film is driven at a constant speed, so that the sound can be recorded at any point. Instead of the usual distance of 75 perforations from the corresponding frame, the sound can be placed immediately opposite each frame, thus avoiding the difficulties arising from cuts and repairs. After being wound up as used during projection, the film is not rewound but is picked out from the inside of the reel to be projected again. This operation is done by conical rollers. C. H. S.

Industry Earns 95 Millions in 1930. *Mot. Pict. Herald*, **103**, Sect. 1, May 9, 1931, p. 11. Gross earnings reported by 12 companies were $421,927,400 for 1930 compared with a total for 9 companies in 1927 of $168,060,696. Net income for 16 companies amounted to $94,833,067 in 1930 compared with $45,218,670 in 1927 for 12 companies. Gross earnings are not included for Paramount, Universal, Eastman Kodak Company, and National Screen. G. E. M.

Sound-on-Film for Home Movies. A. J. KOENIG. *Electronics*, May, 1931, p. 621. A discussion of the problems involved in the recording of sound on 16 mm. film. A. C. H.

A Dynatron Vacuum Voltmeter. RINALDO DE COLA. *Electronics*, May, 1931, p. 623. This paper is concerned with the use of the pliodynatron as a means of obtaining considerably greater sensitivity than is possible with single-tube voltmeters. A. C. H.

Acoustic Treatment for Sound-Picture Theaters. VESPER A. SCHLENKER.

Electronics, May, 1931, p. 625. A general discussion of the treatment of acoustics in motion picture theaters which cannot be usefully abstracted.

A. C. H.

The Unit of Photographic Intensity. The Present Status of Its Standardization. Loyd A. Jones. *J. Opt. Soc. of America*, June 1931, p. 361. The International Congress of Photography undertook several years ago to bring about a standardization of the source of light to be used in photographic sensitometry, the interests of this country being represented by a committee of the Optical Society of America. This paper is concerned with the present status of the project and contains recommendations for a unit of photographic intensity which, however, have not yet been ratified by the national committees represented at the Congress. A new report dealing with certain features of the recommended light source will be presented at the 8th International Congress to be held in Dresden during August, 1931.

A. C. H.

Patent Review on Receiver Circuits and Tubes. John J. Rogan. *Electronics*, June, 1931, p. 672. A brief review of the present patent situation with respect to vacuum tubes and receiving circuits. The important patents with serial numbers and expiration dates are given.

A. C. H.

Glow Lamp Sound-on-Film Recording. Verne T. Braman. *Electronics*, June, 1931, p. 679. A description of the glow lamp method of sound-on-film recording with special reference to the proper design of the glow lamp. The author has devised a special type of three electrode glow lamp, the function of the third electrode being to make the ignition voltage equal to the extinguishing voltage by allowing a very small modulated ionizing current to flow at all times. This ionizing current is independent of the modulated current between the normal electrodes, and causes the gas to remain ionized with a faint cathode glow even when the normal lamp current is reduced to zero.

A. C. H.

Automatic Time Delay Relay. C. Huff. *Proc. I. R. E.*, **19**, June, 1931, p. 1019. In certain hot cathode, mercury rectifier tubes, no plate voltage should be applied for at least thirty seconds after the filament current is turned on. By means of an automatic time delay relay, made up of a system of relays and a telechron clock motor, this thirty-second delay is automatically taken care of. To prevent breaking the high potential plate circuit, separate transformers are used for plate and filament potentials. The relay closes the primary circuit of the plate transformer. A complete description of the relay is given, aided by a schematic diagram.

A. H. H.

A Non-intermittent Camera. William Stull. *Amer. Cinematographer*, **12**, June, 1931, p. 12. The Moreno-Snyder camera, now made in Hollywood, uses an optical intermittent system consisting of eight rectangular plano concave lenses which supplement the regular lens of the camera and move with the film to correct its continuous motion. The effect is a steady motionless image upon each frame. The lens wheels are clamped and cemented so they cannot get out of alignment, it is claimed. A variable slit at the aperture takes the place of shutter control for variation of exposure and the large maximum aperture of 360 degrees makes possible a tremendous range not available in ordinary apparatus.

The camera includes a finder system operating through a prism, placed in front of the aperture by a manual control, and automatically thrown clear whenever the camera is started; also a novel photo-cell exposure meter which actuates a dial at

the rear of the casing to indicate correct exposure for the particular lens and slit adjustment used. An artificial frame line is put in the film by a masking device in the matte box which must be set after focusing and adjusting the lens aperture. The new camera is stated to be noiseless and capable of operating at any speed between eight and three hundred frames per second. A. A. C.

1930 Equipment Exports Gain. N. D. GOLDEN. *International Photographer*, **3**, April, 1931, p. 13. Preliminary figures of the Bureau of Foreign and Domestic Commerce show that exports of American motion picture equipment increased $4,000,000 over the 1929 estimate, or approximately 80 per cent. Europe is our best customer, the Far East second, and Latin America third. Sound apparatus, which is this year reported separately for the first time, accounts for four-fifths of the total volume of export business. A. A. C.

Stewart-Warner 16 Mm. Camera. *International Photographer*, **3**, April, 1931, p. 25. A manufacturer's announcement states: "The camera is compact and light, 2 by 5 by 8 $^3/_4$ inches, is made of duralumin throughout, with an etched satin-finished case; weighs 3 $^1/_2$ pounds when loaded with 100 feet of film, and will retail at $50.00, with carrying case." Experimental work on the camera was done in Hollywood and the plant was moved to Chicago in February. A. A. C.

The Spicer-Dufay Process of Color Cinematography. *Brit. J. Phot.*, **78**, June 5, 1931, p. 22 (Color Suppl.). This color process uses a mosaic filter film mechanically prepared. Dyes are applied in squares to the number of 350 per inch by means of an ink-resisting printing process on the film base. The emulsion, coated on top of a protective coating over this color mosaic, is specially made for the purpose, and consists of grains of relatively large size and great sensitiveness together with a finer material. The original negative image is obtained chiefly on the large grains leaving the fine grained part for development of the reversed positive. A projection printing method has been worked out for the making of prints which is claimed to be highly successful. The Spicer Company expects to extend this method to the production of prints on a white base material, to lead to a cheap and easy process of color photography for general use. A. A. C.

ABSTRACTS OF RECENT U. S. PATENTS

1,805,511. **Apparatus for Making Animated Pictures.** A. W. CARPENTER. Assigned to Audio-Cinema, Inc. May 19, 1931. An animated picture photographing apparatus having a work table on which a picture sheet is spread flat adjacent a compressible pad. A rigid support is provided for the pad. The picture is pressed down upon the pad and flattened thereagainst by means of a glass plate. The picture is supported by means of end clamp devices which permit the picture to be shifted away from the pad with the plate when the plate is raised preparatory to a subsequent animated picture operation. Successive pictures are produced and then photographically reproduced upon a film in proper sequence so that when the film is projected the object will appear to move on the projection screen.

1,805,579. **Portable Motion Picture Film Carrier.** L. GOLDHAMMER. Assigned to Agfa Ansco Corp. May 19, 1931. A portable film carrier which contains a film transporting drum including a swinging holder containing pressure rollers for pressing the film toward the film transporting drum. A locking device is provided for maintaining the film in position on the film transporting drum wherein release means may be actuated when removing the film from the film transporting drum.

1,804,685. **Continuous Sound Picture Projection.** W. K. GRIMM. May 12, 1931. Motion picture film is driven continuously in relation to a light reflecting mirror disposed in alignment with a lens system. A framing mask is arranged to overly the film and may be adjusted with respect to the reflecting mirror to alter the position of the framing mask with respect to the mirror. In as much as the film is moved continuously in the projector of this invention for the projection of pictures, the reproduction of sound from the film may be obtained from the same point in the longitudinal length of the film and not displaced in position along the film as heretofore has been necessary.

1,805,948. **Printing Machine for Sound and Picture Records.** G. LANE. Assigned to Audio-Cinema, Inc. May 19, 1931. A machine which may be used for printing both the sound and picture records on a film. The printer includes an aperture ring having thereon a plurality of apertures of different widths and extents, so arranged in relation to the printing aperture, that one of the ring apertures may be made to occupy the desired position for printing either the sound or picture records, as desired. Motion pictures are printed through one aperture while the sound is printed through another aperture in a position displaced longitudinally of the film and adjacent one edge of the film out of line with the picture.

1,805,594. **System for Combined Television and Communication.** R. D. PARKER. Assigned to American Telephone and Telegraph Co. May 19, 1931. Two people while being televised may converse with each other by telephone instruments which do not interfere with the production of a full-face image of each party in the line of vision of the other and so placed as to produce the illusion of a face-to-face conversation. The telephone instruments are outside the field of

view of the scanning apparatus in the booth which the persons occupy for transmission and reception of the television image. Each booth is equipped with an image integrator and analyzer and a telephone transmitter and loud speaker shielded from view of the television devices.

1,806,122. **Motion Picture Film Reënforced by Metal Strips.** A. H. SMITH. May 19, 1931. The edges of the film at the perforations are reënforced by metal strips secured through the perforations by means of tongues which are punched from the strip in forming the desired perforations therein, the said tongues being bent around the transverse edges of the film perforations to secure the reënforcing strip to the film. The securing tongues are so arranged that the ends of the forwardly extending tongues extend beneath the ends of the rearwardly extending tongues, thus forming a positive protection for the film.

1,806,190. **Method of Obtaining Stereoscopic Impressions of Motion Picture Images.** N. ARFTSEN. May 19, 1931. Stereoscopic pictures are produced by utilizing light of different wave-lengths for each eye of the observer so as to bring the eyes into different states of adaptation, forming right and left images with sufficient rapidity to produce persistence of vision. A beam of light neutralizing the image which the eye should see is directed into each eye alternately. The projection system avoids the necessity of observing a picture through some form of rotary shutter device placed in front of the observer's eyes. Motion picture film having pictures arranged side by side is employed in the stereoscopic system. The system is based on the fact that the ability of one eye of perceiving or seeing a certain view remains unaffected by a light impression created in the other eye providing that such light impression is entirely uniform and homogeneous. A sudden light such as a flash or a short projection of a picture will be perceived by the human eye only after a certain interval has elapsed. The length of this interval, *i. e.*, the interval between the actual emission of light rays and their perception by the human eye and brain, is referred to as "perception time." The same depends to a large extent on the intensity of the light projection. The stronger the light, the shorter will be the perception time. One and the same light projection appears in a lesser degree of brightness, if the eye receives an additional light. This additional light may be thrown into the eye from the side or from some other place surrounding the light projection. The stronger such additional light is, the longer will be the perception time of the light projection. Under the condition that the additional light appears in a certain (red) color, only the perception time of the same (red) colored light will be prolongated and the perception time of the contrasting (green) light will be of a shorter endurance.

1,806,375. **Photographic Recording by Radioactive Means.** JOHN A. TIEDEMAN. Assigned to General Electric Co. May 19, 1931. Figures or characters to be recorded on film are preferably cut into a recording drum or other surface which may be brought into contact or close proximity to the film and the depressions caused by the cut-in figures are then filled with a radium salt or other suitable radioactive substance. Then when the unexposed film is brought into contact with the drum those portions of the film opposite the figures are exposed to the action of the radioactive substance so that when the film is developed these figures are clearly indicated thereon. A permanent record from which film may be printed is provided on the engraved surface of the drum wherein the depressions are filled with the radioactive salt.

1,806,452. **Method of Producing a Background for Motion Pictures.** F. GULGORA. May 19, 1931. A motion picture is reproduced with a background produced by projecting with an ordinary motion picture machine a given picture substantially centrally of the screen, using a dissolving lantern slide projector at the same time for projecting different still pictures on said screen around the motion picture without overlapping it, and simultaneously using a second dissolving lantern for projecting a still picture around the second picture projected whereby the picture on the screen will consist of a motion picture and two still pictures. Two or more motion pictures may be used together, or a single motion picture with one or more projecting lanterns, may be used at the same time, and caused to present independent pictures to be projected on a screen at different points in such a way as to produce a single effect.

1,806,617. **Synchronized Photographic and Disk Recording and Reproducing Mechanism.** C. W. EBELING. May 26, 1931. Duplicate motors are provided for driving separate disk records for a talking picture system. The driving motors for each disk record are interconnected through differential gearing to the motion picture projector. Governing means are provided for each record table driven by the separate motors for maintaining the record tables in synchronism with the operation of the projector. The system is also applicable to a camera and disk record recording system for sound pictures.

1,806,638. **Scanning Disk for Television System.** PIERRE MERTZ. Assigned to American Telephone and Telegraph Co. May 26, 1931. Scanning disk for television systems which is provided with apertures aligned in different concentrical circles in overlapping relationship. The entire area of a field of view is repeatedly scanned and then each scanning line of the entire path of one complete scanning operation partially overlapped with two scanning lines of a preceding scanning operation for securing detail in the scanning operations.

1,806,744. **Silent Drive Mechanism for Talking Motion Picture Machines.** LEE DE FOREST. Assigned to General Talking Pictures Corp. May 26, 1931. Separate and independent drives are provided for the picture recording or projection and sound recording or reproduction processes in the camera or projection machine. The film feeding sprockets are driven as usual while the phonofilm attachment is independently driven for reducing machine noises to a minimum at the sound slit to avoid interference with the recording of sound.

1,806,745. **Sound Producing Device Using Modulated Flow of Gas.** Assigned to General Talking Pictures Corp. LEE DE FOREST. May 26, 1931. A screen is employed as one of the electrodes in a sound reproducing system. A gas is modulated in accordance with voice currents and the flow thereof with respect to the screen electrode modified for the reproduction of sound. An electric tension is established between the screen-like electrode and an adjacent electrode for the reproduction of sound in accordance with the modulated flow of gas.

1,806,746. **Luminous Discharge Tube for Recording and Reproducing Sound.** LEE DE FOREST. Assigned to de Forest Phonofilm Corp. May 26, 1931. The cathode in a luminous discharge tube is shaped to have a uniform thickness but a width which varies along its central axis so that a varied voltage across the electrodes will produce a varying negative glow which is exaggerated. The chief advantage of this kind of glow discharge tube is to emphasize the higher harmonics of the recorded sound which are normally of relatively low intensities, and are as

a consequence inadequately recorded and inadequately reproduced by the reproducing system, particularly the loud speaker elements thereof.

1,807,270. **Visionograph Record and Method of Making the Same.** CHARLES ALBERTI. May 26, 1931. Two record tables are geared to operate synchronously with a television scanning disk. The magnetic engraving devices associated with each disk record are so associated with the visual recording circuit and sound recording circuit that synchronous sound and picture records may be made. One engraving tool is connected in series with the light-sensitive device which is controlled by the operation of the scanning disk for making a record of the visual signaling energy. The other record table carries a disk which is engraved by a device under control of the sound pick-up circuit. The gearing system insures synchronous operation of the recording and scanning systems.

1,807,327. **Repeating Stereopticon.** J. F. STUBNER. May 26, 1931. Automatic projecting machine for stereopticon slides wherein there is provided a magazine for a plurality of slides above the beam of light. The foremost slide is moved vertically into the path of the beam and the next foremost slide is moved into the path of the beam so that its lower edge strikes against the top edge of the first slide to eject the first slide. The ejected slide is automatically moved into an upright position and restored to the rear of the magazine of the stereopticon for the repeat projection process.

1,807,464. **Scanning System for Television.** JOHN L. BAIRD. Assigned to Television, Limited, London. May 26, 1931. A scanning system for television which includes an exploring device which provides a series of laterally displaced images whereof the maximum displacement is a fraction of the width of the picture, a plurality of light-sensitive cells (or light-sources) spaced apart across the picture and each appropriated to one zone the width of which is equal to the said maximum displacement, and means for exposing the light-sensitive cells (or light-sources) successively during successive cycles of operation of the exploring device. The scanning means has a maximum displacement sufficient to cover an area which is a portion only of a given field of vision with respect to any one electroöptical element. The electroöptical elements are so disposed that each is appropriated to a different portion of the field of vision by the scanning means. The electrooptical elements are rendered operative, one at a given time, so that elements of the picture are exposed to scanning action successively.

1,807,465. **Scanning System for Television.** JOHN L. BAIRD. Assigned to Television, Limited, London. May 26, 1931. A scanning device for use in television where a rotating screen is interposed between a light source and an object to be scanned, the screen having a plurality of series of spirally arranged apertures. The apertures in the different series are spaced radially of the screen so that light rays will be passed from the light source across different sections of the object simultaneously. There are a plurality of light-sensitive devices each positioned to receive light from one of said sections of the object only.

1,807,602. **Circuit for Recording and Reproducing Sound from Film.** ARTHUR STANLEY RADFORD AND MICHAEL BOWMAN MANIFOLD. Assigned to Victor Talking Machine Company. June 2, 1931. A circuit for the reproduction and the recording of sound where two thermionic valves are arranged in opposition and having a common output circuit. A light-sensitive device is con-

nected across the input of each valve. One of the valves is subjected to variable light under modulation control by a film.

1,807,737. **Home Projector for Films of Different Sizes.** L. GOLDHAMMER. Assigned to Agfa Ansco Corporation. June 2, 1931. A home type motion picture projector having an attachment for adapting the machine to films of different sizes. A plate carrying a film guide and film sprockets is bodily removable from the projector and interchangeable with another plate. The different size sprockets and film guide are mounted on the interchangeable plates to accommodate the machine to different size films.

1,807,805. **Preparation of Colored Reproductions by Imbibition.** BERTHA SUGDEN TUTTLE. Assigned to Technicolor Motion Picture Corporation. June 2, 1931. A method of imbibition printing for gelatin films which comprises wetting a suitable printing matrix bearing the image to be reproduced in the several degrees of development corresponding to the several contrasts presented therein, with a solution containing a dye having a marked penetrability of the gelatin film to be printed and a second dye having relatively low penetrability or dispersion with respect to said film—and contacting the thus wet matrix with the gelatin film.

Multicolor films are produced using a transparent film to which there is applied a coating of a solution containing gelatin, a hardening agent such as potassium dichromate, and usually an organic acid such as acetic acid. The coating thus formed is then allowed to dry rapidly and is subsequently hardened to the desired degree. A plurality of matrix films, each bearing an image to correspond to one (or more) of the primary colors or to each of two (or more) complemental colors appearing in the reproduction to be made, is next prepared, as by suitably exposing and developing or light printing and developing a photographic film therefor. For example, where the complementary colors, red and green, are to be provided, a film matrix may be prepared and developed to correspond to the red portion of the images in the subject to be reproduced and a second matrix film may be developed to correspond to the green portions thereof.

1,808,046. **Film of Magnetizable Material for Episcopic Projection.** H. KUCHENMEISTER. June 2, 1931. A film of magnetizable material having a magnetic sound record recorded thereon. The film consists of a metal band of magnetic material having a magnetic record recorded directly thereon. The band may also carry pictures on the surface thereof for episcopic projection. The magnetic record may operate over the entire surface of the band coördinate with the record carrying the pictures for episcopic projection.

1,808,077. **Sound Picture Screen.** W. J. SCHOONMAKER. June 2, 1931. A sound picture screen comprising a woven cloth formed with interstices for the passage of sound through the screen, where the surface of the cloth is ridged to provide for the evenly diffused reflection of the picture displayed.

1,808,078. **Non-inflammable Sound Picture Screen.** W. J. SCHOONMAKER. June 2, 1931. A sound picture screen comprising a woven fabric formed with interstices in the weaving among the threads. The fabric is treated with a water-proof solution. There is a plastic non-inflammable and water-proof chemical compound applied to both sides of the treated fabric. The plastic compound covers the thread of the fabric and acts as a seal to prevent deterioration of the ingredients of the fire-proof solution from exposure to air and making the screen

non-inflammable, water-proof, and washable. The plastic compound is sufficiently thin so that it does not clog up or entirely close the interstices so that sound from a loud speaker behind the screen readily passes through the interstices.

1,808,137. **Electroöptical System for Television.** RALPH V. HARTLEY. Assigned to Bell Telephone Laboratories, Incorporated. June 2, 1931. A television system employing a separate line or channel for each elemental area of the field of view. The energy controlled by each elemental area of the field of view at the transmitter is given a distinctive characteristic, preferably a frequency characteristic such that the currents for all or many of the elemental areas may be superimposed in a single physical circuit or medium and separated again at the receiver, and each elemental area at the transmitter acts continuously in its control of its channel so that maximum illumination at the receiver is obtained. Separate piezoelectric crystals of different frequency characteristics are arranged to resonate simultaneously for controlling light in a television analyzer.

1,808,252. **Film Gate.** FREEMAN H. OWENS. June 2, 1931. The film is maintained in sliding contact with the light aperture by means of a spring pressed shell adjacent the film gate, the shell being movable with respect to the light aperture. A locking device is provided for maintaining the shell in a predetermined position with respect to the light aperture.

1,808,497. **Adjustable Support for Motion Picture Projection Machines.** A. DINA. Assigned to International Projector Corp. June 2, 1931. The projecting machine is mounted for adjustment in an angular direction in a vertical plane for aligning the projector with the screen in the theater. The patentee points out that motion picture projectors are commonly mounted at the top and rear of a theater and must be adjusted so as to project the picture downwardly upon the screen. The patentee provides an angularly disposed arm which may be adjusted both telescopically and by an expansible and contractible screw joint for obtaining the desired angular disposition of the motion picture projector.

1,808,864. **Cinema Projection Screen.** JULES E. PALLEMAERTS. May 26, 1931. A fabric base is provided for the screen with a transparent adhesive coating on the front of the fabric screen. A plurality of glass pyramids are placed on the adhesive coating with their apexes projecting from the base, and a second coating of the transparent adhesive flowed over the front surface of the screen so as completely to embed the pyramids therein. The purpose of the screen is to obtain brilliant illumination by reason of the minute reflected rays of light between the sides of the pyramids.

1,897,940. **Tone Quality Control Apparatus.** J. E. STAFFORD. June 2, 1931. The sound pick-up circuit leading to the audio frequency amplifier in a sound reproducing system is governed by an adjustable impedance circuit which controls the tone quality of the reproduced sound. The modulating circuit which may be controlled by the phonograph pick-up or a microphone circuit connects to the input of the audio frequency amplifier system. The tone control comprises a resistance connected directly across the modulated current generating source and an adjustable filter circuit connected between a point intermediate the ends of the resistance and the amplifier.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

BOOK REVIEWS

Recording Sound for Motion Pictures. *Academy of Motion Picture Arts and Sciences.—McGraw-Hill Book Co.*, New York, N. Y., 1931, 404 pp. Price $5.00.

A symposium of articles by leading authorities in the various phases of the art of recording and reproducing sound motion pictures. This book brings together under one cover for the first time a complete picture of the sound motion picture field, interesting not only to the sound engineer, but to the whole motion picture organization.

Arranged under five general heads, practically every phase of the art of sound recording is covered, from the source of the sound motion picture of today to the organization of the personnel of a sound recording organization.

Sound recording on disk and film, both the variable area and the variable density methods, is covered by articles explaining the theory and operation of individual designs. Circuits, amplifiers, and associated equipment and methods are illustrated and described.

Four interesting articles present a lucid picture of what goes on behind the scenes in the film processing laboratories and in the editing and assembly rooms.

Articles on acoustics give an idea of the problems encountered by acoustical engineers in the building of studios and theaters. Little is known regarding this phase of the art by the average person, and these articles give some very interesting information.

The projecting and reproducing of sound motion pictures is explained in articles on both the Western Electric and the RCA Photophone systems.

The book is well ended by a glossary of motion picture terms used in the laboratories, the studios, and the theaters.

A. H. Haak

Patent Law. Fred H. Rhodes. *McGraw-Hill Book Co.*, New York, N. Y., 1931, 207 pages.

This book is highly recommended to everyone coming even remotely in contact with patents and inventions. The work is easily read, but is surprisingly comprehensive. Most of the points with which the layman, and especially the inventor, should be familiar, are covered.

There is a brief résumé of the development of patent law. Other chapters cover in a concise and clear manner what persons are entitled to a patent, the differences between invention and discovery, and what constitutes novelty and patentability. Several sections deal with the application and the obtaining of the patent itself. The principal points covered here are the date of invention, abandonment, the form of the application, and the prosecution and amendment of the application. Other chapters deal with the legal aspects of a patent after it has been granted. These include a chapter on the rights conferred by a patent, a chapter on infringement, and another on testing the validity of a patent. A closing section deals with the rights of employers and employees, and the policy

in respect to patents generally. An index of citations is included and a subject index.

The language is non-technical and the style direct and clear. As indicated at the beginning of the book, it is written especially for chemists, inventors, and executives. It is one of the best of such works.

A. H. NIETZ

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CONTRIBUTORS TO THIS ISSUE

Batsel, C. N.: Born 1898, at Fulton, Kentucky. B.M.E., University of Kentucky, 1919; engineer, Empire Gas and Fuel Company, 1919–21; engineer, Tennessee Copper and Chemical Company, 1921–23; research engineering department, Westinghouse Electric and Manufacturing Company, 1928–30; RCA Victor Company, 1930 to date.

Brackett, F. P.: Born June 16, 1865, at Provincetown, Mass. A.B., Dartmouth College, A.M., Sc.D. Instructor, Mathematics and Astronomy, 1888–90; director of observatory, Pomona College, 1890 to date. Member Smithsonian Astronomical Expedition to Africa, 1911; Mt. Whitney Expedition, 1913; director, Solar Eclipse Expedition to Isthmus, Santa Catalina Island, 1923. Editor, *Astronomical Publication of Pomona College.*

Hardy, A. C.: See March, 1931, issue of JOURNAL p. 389.

Kellogg, E. W.: Born 1881, at Vineland, N. J. C.E., Princeton, 1906; Civil Engineering, 1906–8; Cornell 1908–9; test engineer, Commonwealth Edison Company, 1909–10; instructor, electrical engineering, University of Missouri, 1910–15; assistant professor, electrical engineering, A & M College (Texas), 1915–16; assistant professor, electrical engineering, Ohio State University, 1916–17; research laboratory, General Electric Company, 1917–30; engineering department, RCA Victor Company, 1930 to date.

Kelley, W. V. D.: See April, 1931, issue of JOURNAL, p. 519.

MacKenzie, Donald: Born December 20, 1887, at Weatherford, Texas. Ph.D., Johns Hopkins University, 1914; assistant in astronomy, Johns Hopkins, 1914–17; assistant and associate physicist, Bureau of Standards, 1918–20; engineer, Western Electric Company and Bell Telephone Laboratories, 1920–29; consulting engineer, Electrical Research Products, Inc., 1929 to date.

Pineo, O. W.: Born September 27, 1908, at Katahdin Iron Works, Maine. S.B. in physics, Massachusetts Institute of Technology, 1929; assistant, department of physics, Massachusetts Institute of Technology, 1929 to date.

Schlanger, Ben: Born November 20, 1904, at New York, N. Y. Beaux Arts Institute of Design, 1925; theater architect, 1925 to date. Co-author of *American Theaters of Today,* Part II.

White, D. R.: Born at Berea, Ohio. B.S., Baldwin-Wallace College, 1922; Ph.D., physics, Columbia University, 1927; sensitometric and research work, du Pont Pathé Film Manufacturing Corporation, 1927 to date.

SOCIETY ANNOUNCEMENTS

INTERNATIONAL CONGRESS FOR PHOTOGRAPHY

DRESDEN, AUGUST 3–8, 1931

For the first time the International Congress for Photography is to be held in Germany. Plans for the Congress are in the hands of an active committee composed of well-known representatives of photographic research.

Professor Albert Einstein as honorary chairman will open the Congress with a lecture.

The activities of the Congress comprise four sections:

I. Photography
  (*a*) Theoretical principles
  (*b*) Practical photography
II. Cinematography
III. Application of photography and motion pictures to science and engineering
IV. History, bibliography, legal problems

In conjunction with the Congress an exposition of apparatus and the most recent results of scientific photographic research will be held.

Lectures which have been announced so far include the following subjects: sensitometry, latent-image, cinematography, color photography, astronomy, medical and x-ray photography, sound film, technic of reproduction, history of photography, *etc.*

The large program of lectures will offer an opportunity to obtain the most recent information regarding all branches of photographic research. Among others, Professor Dr. Eggert of Leipzig will speak on the color film; Professor Dr. Freundlich, Potsdam, on photography in astronomy; Professor Dr. Goldberg, Dresden, on the experimental principles of the sound film; Professor Hertzberg, Stockholm, on the pictures of the Andree expedition; Professor Ponzio, Turin, on photography in medicine and x-ray technic; Dr. S. E. Sheppard, Rochester, U. S. A., on the latent-image; and Joris Ivens, Amsterdam, on present and future artistic problems of musical film with demonstration of an international selection of particularly representative films.

The Congress, therefore, will be of great interest to all who work with any branch of photography.

Beautiful Dresden, with its wonderful environment, is a suitable setting for this convention and many delegates to the Congress may wish to make use of the opportunity to spend their vacations there.

A varied entertainment program will be of interest to the delegates. Among other things the delegates will have an opportunity to inspect the sound film studio of Ufa and to observe a sound film recording on August 8th in Berlin, Neubabelsberg.

President Crabtree has appointed Dr. S. E. Sheppard as official delegate to represent the S. M. P. E. at this Congress.

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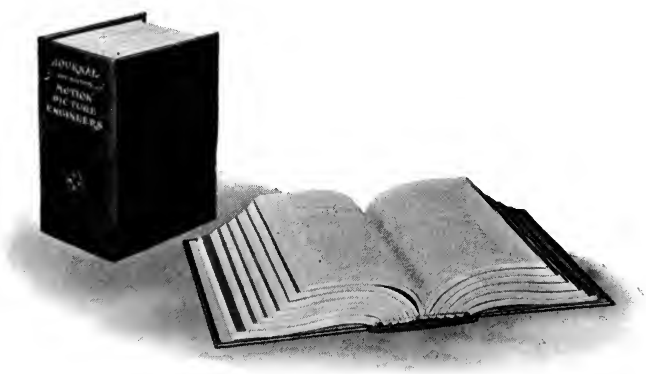
The binder shown in the accompanying illustration serves as a temporary transfer binder or as a permanent cover for a complete year's supply of JOURNALS. It is made of black crush fabrikoid, with lettering in gold. The binder is so constructed that each individual copy of the JOURNAL will lie flat as its pages are turned. The separate copies are held rigidly in place but may be removed or replaced at will in a few seconds.



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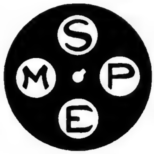

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of $1.00.

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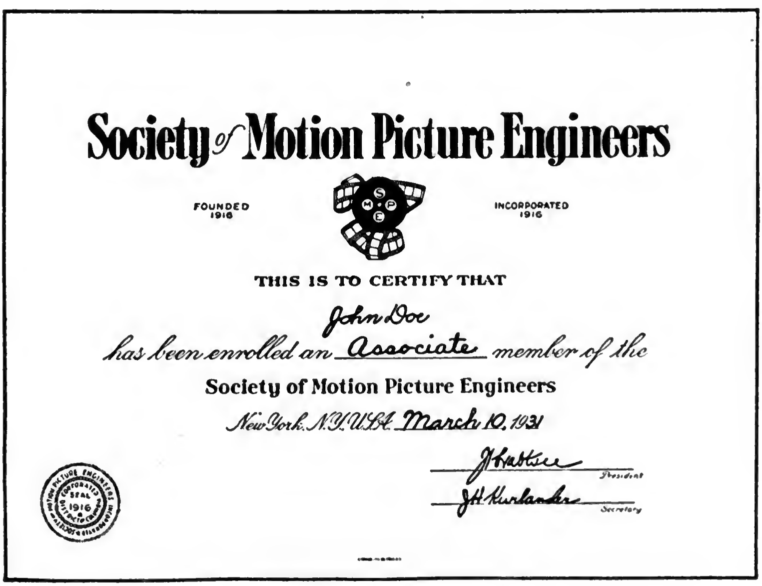
Associate members of the Society may obtain the membership certificate illustrated below by forwarding a request for the same to the General Office of the Society at 33 W. 42nd St., New York, N. Y., accompanied by a remittance of $1.00.



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OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

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RECENT CONTRIBUTIONS TO LIGHT VALVE TECHNIC*

O. O. CECCARINI**

Summary.—*This paper describes structural changes made in light valves with the object of improving their quality, stability of operation, and efficiency, the most important being the introduction of damping to off-set resonance. These features are chiefly considered from the standpoint of production requirements and engineering economies. The shapes of the exposure waves for the two outstanding types (single and double ribbon) are considered. A new type of oscillograph (synchronous slit type) is described. This oscillograph permits the behavior of the valve to be observed at any frequency within the recording range.*

The apparatus which is most likely to receive the greatest possible attention in the way of improvements by the operating personnel, is that which seems inherently too delicate to stand the hardship of motion picture sound recording.

No apparatus is too delicate for use in the physical laboratory, but when it is sent out into the field, applied to production, and handled by less skilled personnel, it must often be substantially remodeled, divested as much as possible of its weak features, and its economic performance must be assured. This transformation is sometimes prevented by a too great demand for immediate practical application; improvements must then follow as dictated by practice.

The original form of the light valve as applied to recording sound on film could have been substantially so described without doing injustice to pioneers in this particular field. It was very delicate, and it had a natural period within the useful recording range. The exposure wave was appreciably distorted at high frequencies, and the delicate ribbons when vibrating did not move in an absolute plane, but had a tendency to rock a great deal, and occasionally would touch the pole piece if the height of the ribbon were not properly adjusted.

The light valve was, beyond doubt, and probably still is the weakest link in the chain of the recording apparatus. It has received considerable attention in the laboratories and studios, and genuine efforts

*Presented at the Spring, 1931, Meeting at Hollywood, Calif.

**Metro-Goldwyn-Mayer Studios, Culver City, Calif.

have been made toward the elimination of its undesirable features.

It will be interesting to review the various changes made in chronological order.

Fig. 1 is a schematic representation of the original form of light valve when first applied to the recording of sound on film. The two ribbons tend to move apart under the applied tension, but are prevented from doing so by four metal springs which permit correct adjustment of each ribbon with respect to the other, and also with respect to the light passage through the pole piece. The ribbons rest on bakelite bridges which act also as insulators. The length of the vibrating section in each ribbon is approximately $^7/_8$ inch, and originally it was recommended to tune the valve to 7,000 cycles.

One of the chief difficulties encountered was the shifting of the

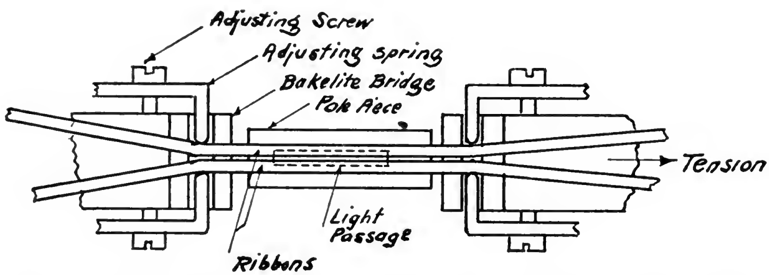


FIG. 1. Form of light valve first applied to the recording of sound on film.

ribbons upon the bakelite bridges as a result of heavy impulses, the restoring force apparently being insufficient to overcome the friction between the ribbons and the bridges and, therefore, causing a permanent change of the ribbon spacing. As a result of this difficulty valves had to be checked very frequently.

The resonance peak occurring at 7,000 cycles was also found to be a source of trouble. This frequency is well within the accepted range, and the equalizer used to offset the abnormal response of the valve at that frequency did not prove entirely satisfactory.

Two important changes then appeared highly desirable: a means for preventing the ribbon from losing its correct adjustment, and the shifting of the tuning frequency to an appreciably higher value without an effective increase in tension.

Luckily, a very simple expedient presented itself for accomplishing both objectives at the same time. It consisted in gluing the ribbons

between insulating spacers in the manner shown in Fig. 2. These spacers were conveniently cut from paper 0.002 inch thick and measuring approximately 0.040 inch by 0.080 inch. The mode of procedure was very simple, as these spacers were applied after the valve had been correctly spaced and tuned to 7,000 cycles as under ordinary conditions. This amounted to shortening the vibrating loop from $^7/_8$ to about $^{11}/_{16}$ inch, and as a result, the frequency of resonance changed from 7,000 to about 9,000 cycles without having to increase the effective tension; and the ribbons being definitely clamped with respect to each other, would remain correctly adjusted throughout their entire life.

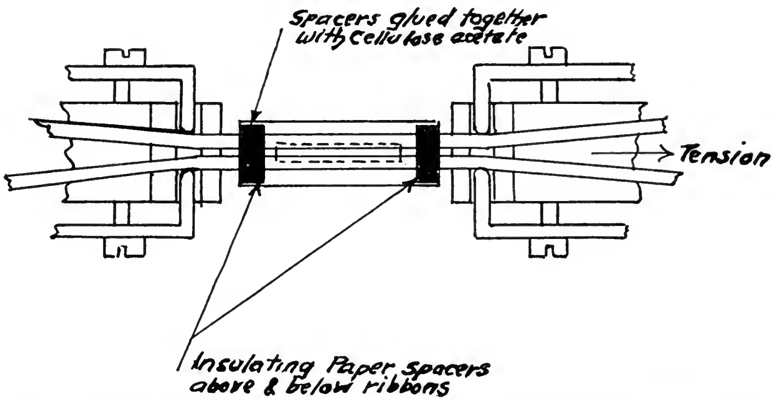


FIG. 2. Showing manner in which ribbons are glued between insulating spacers.

The general improvement of quality in the high frequency range was found to be considerable, and the advantage of a higher tuning frequency was soon recognized. We began to use paper spacers in January, 1929, and, several months later, Electrical Research Products, Inc., introduced a new valve with an appreciably shorter vibrating loop, although the insulating paper spacers seem to have been an exclusive feature of the valves used at the Metro-Goldwyn-Mayer Studios.

The amplitude of the resonance peak, ordinarily found in properly adjusted valves, is of the order of 16 to 18 db. above the normal response, or in amplitude ratio we might say that the valve at resonance would vibrate with an amplitude varying from 6 to 8 times greater for the same driving power than at other frequencies.

The above values show that very little force is required to clash

the ribbons at resonance, and experience has amply proved that valve ribbons are broken under clashing conditions. A too high resonance peak, therefore, constitutes a hazard in the life of the valve, and although it can occasionally be tolerated from the standpoint of quality, we must realize that when a valve is broken during a "take," it means loss of time, which in effect is a financial loss. The usual mixer's practice is that of setting the level during rehearsal. But it is seldom

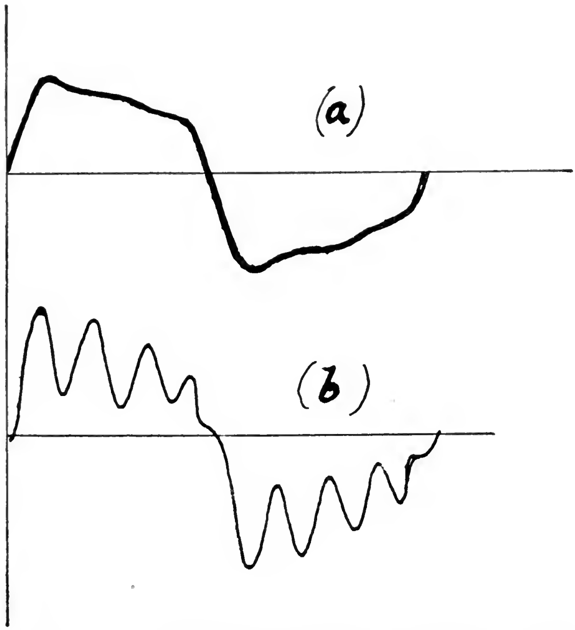


FIG. 3. (*a*) Oscillogram of wave of 1,000-cycle tuning fork; (*b*) wave observed through synchronous slit oscillograph when wave (*a*) is applied to a light valve resonating at 9,000 cycles.

that the actual volume during the take is an exact replica of the rehearsal. Additional takes are not economically justified unless the discrepancy between the rehearsal and the take has been so great as to render the sound record useless.

There are occasions when the dialog is mixed with special effects, such as gun shots, and the action is such that a composite sound record is impossible. The dialog is usually important, the gun shots simply adding dramatic effects. Obviously, the dialog must be intelligibly

recorded, with the result that the valve is badly overloaded by the gun shots.

Let us look briefly into the quality problem. Fig. 3 (*a*) represents a 1,000-cycle wave from an electrically driven tuning fork. This wave is the trace of a curve obtained from a cathode ray oscillograph, and no distortion is introduced by the oscillograph. The wave is far from pure, and a mathematical analysis would show the presence of a ninth harmonic, in addition to other components.

When this wave is applied to a light valve resonating at 9,000 cycles, its mode of vibration as observed through a synchronous slit

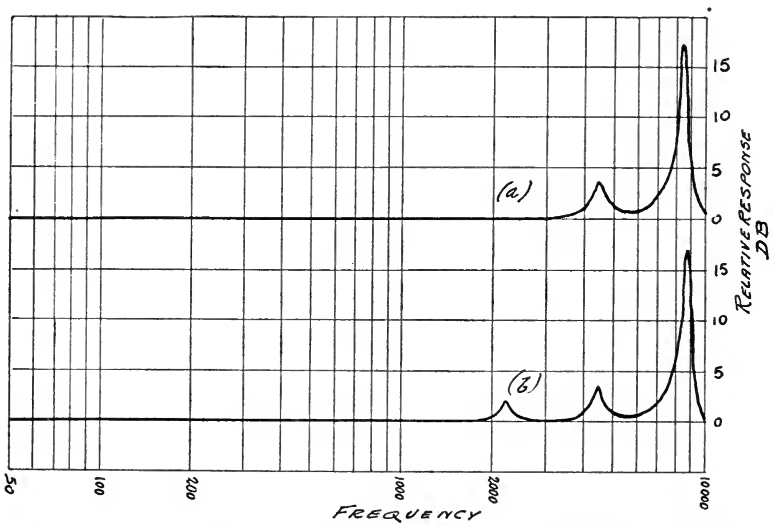


FIG. 4. (*a*) Response characteristic of light valve resonating at 9,000 cycles, operated by oscillator having a slight second harmonic; (*b*) similar to (*a*), but with an additional fourth harmonic in the oscillator.

oscillograph, described later, is that of Fig. 3 (*b*), which is quite different from that of Fig. 3(*a*).

Suppose we should decide to measure the response characteristic of such a valve with an oscillator having a slight second harmonic. We should get a curve such as shown in Fig. 4(*a*). The small peak at 4,500 cycles is caused by the second harmonic, accentuated by the resonance sensitivity of the valve. In a similar way, if the oscillator had in addition a small percentage of the fourth harmonic, we should get a characteristic with a peak at 2,250, and so on (Fig. 4(*b*)). Since speech, music, and sounds in general are characterized by complex

waves of transient and semi-transient nature, a certain amount of distortion by the light valve must be expected. The distortion is noticeable especially when compared with sounds recorded by devices free from resonance features, and a large number of tests have very definitely proved such to be the case.

It is fair to state that the idea of introducing some sort of damping originated from the necessity of increasing the safety limit of the valve and improving its high frequency response.

A close inspection of the mechanical arrangement of a double ribbon light valve will immediately show the difficulty of introducing physical damping, due to the fact that any fluid used would tend to flow between the ribbons by capillary action and give rise to all kinds of

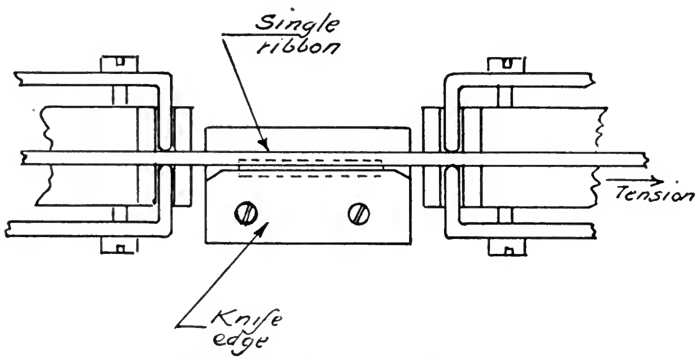


FIG. 5. Schematic arrangement of single ribbon light valve.

troubles; and therefore it becomes highly desirable to eliminate one of the ribbons and operate the other with reference to a fixed knife edge.

The arrangement assumes the form shown schematically in Fig. 5. We might mention at this point that dry damping is impossible unless a totally different form of vibrator is adopted. The single ribbon valve is not new, but has been investigated at various times. When damping is taken into consideration, the single ribbon arrangement offers real possibilities.

We have tested many damping substances and various methods of application. The necessary qualities suitable for damping can be deduced from simple primary considerations. The fluid should have such a nature as to act purely as a mechanical resistance; its consistency must not change with changes of temperature, and the ingredi-

ents must not separate in time. So far, the ordinary automobile cup grease has proved the most satisfactory. The method of application is clearly shown in Fig. 6.

Another interesting feature of the single ribbon valve is that the ribbon and knife edge are located in different planes with respect to

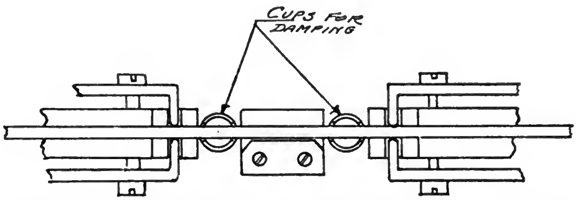


FIG. 6. Showing method of damping the single ribbon light valve, using grease cups.

each other and, therefore, in case of overload the ribbon travels undisturbed past the knife edge. This eliminates the danger of damaging the ribbon, and the resulting wave exposure is appreciably different than that obtained by the double ribbon arrangement under clashing conditions. Curves in Fig. 7 represent an 80-cycle wave under over-

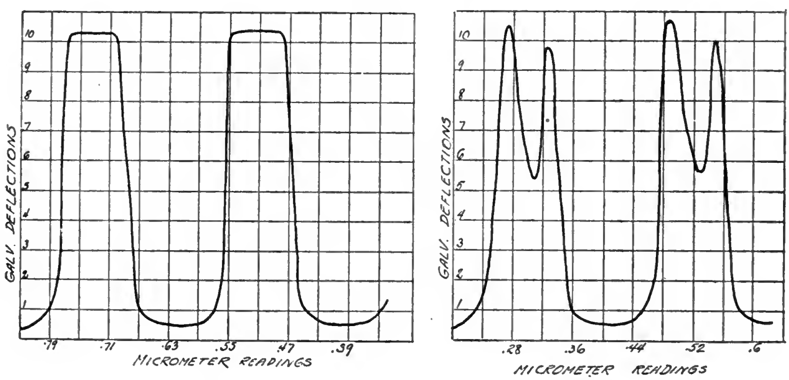


FIG. 7. (*a*) Overloaded 80 cycle negative produced with single ribbon valve; (*b*) 80 cycle negative produced with double ribbon valve under clashing conditions.

load conditions for both types of valve, traced by means of a microphotometer. The dip in the double valve record produced by clashing actually shows 9,000 cycles. The too wide slit of the microphotometer has suppressed this frequency. The general opinion in this studio is that the effect of overloading is appreciably less noticeable

with the single ribbon valve, probably due to the entirely different nature of the distortion in the two cases.

Typical characteristics of undamped (double ribbon) and single ribbon damped valves are given in Fig. 8. It will be noticed that if a small capacity (0.1μf) is shunted across the 500-ohm side of the repeating coil, the frequency characteristic of the damped valve becomes substantially flat up to 9,000 cycles.

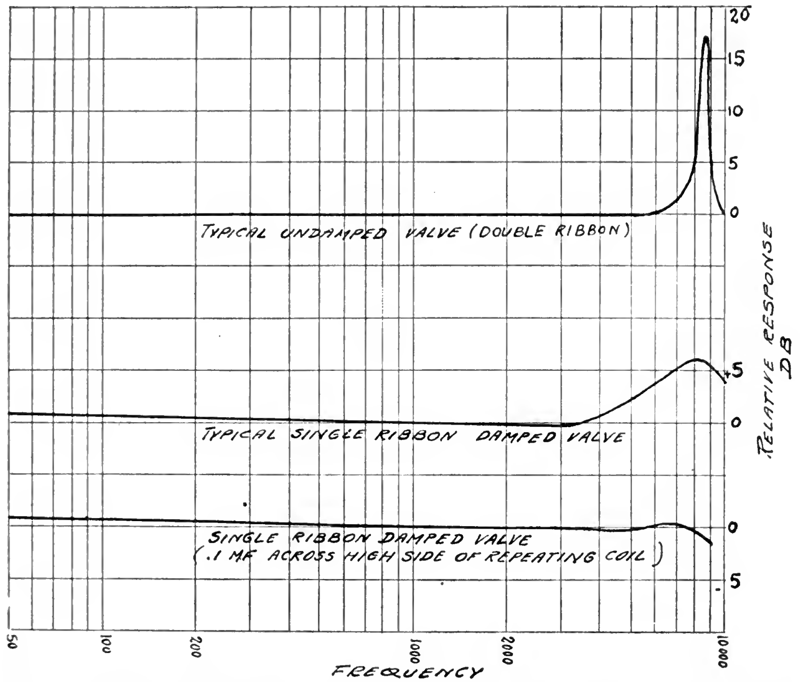


FIG. 8. Typical characteristics of undamped valve (double ribbon), and damped valve (single ribbon).

The difficulty of maintaining correct spacing with bakelite bridges has become more acute with the use of superimposed direct current for background noise elimination. This kind of trouble has been called hysteresis, presumably from its analogy with magnetic hysteresis. In addition, bakelite is quite susceptible to moisture and temperature changes, and although expansion and shrinking did not prove troublesome with the double ribbon valve arranged with paper spacings—because the thickness of the paper itself proved sufficient

to keep the ribbon the correct distance above the pole piece—with the single ribbon valve, bakelite is totally unsuitable as material for the bridge.

As explained above, in the single ribbon valve the ribbon is located in a plane above the knife edge. The distance is 0.001 inch, and we have found it to be a serious task to maintain this dimension with accuracy because of the expansion and shrinkage of bakelite due to changes of atmospheric conditions. We have found a relief for this situation in substituting a metal bridge for the bakelite.

It has been mentioned previously that the ribbons do not move in an absolute plane. This has been observed by means of a microscope fitted with a special objective. Due to the difficulties of arriving at

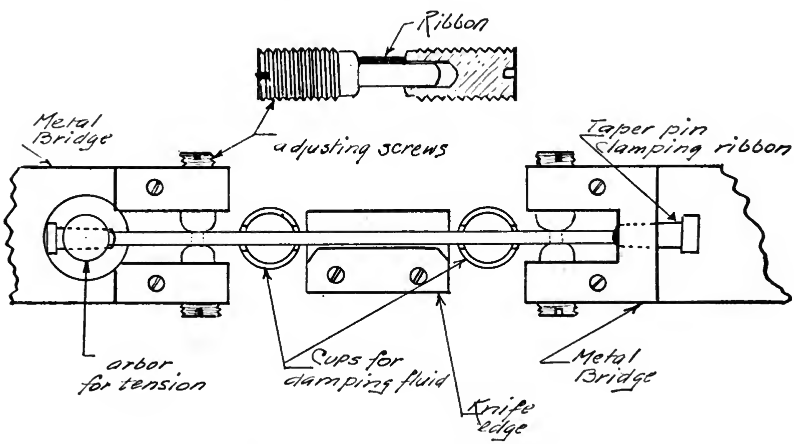


FIG. 9. General arrangement of metal bridge valve.

accurate measurements under such conditions, the following deductions are offered solely as qualitative, and can be observed by anyone, provided, of course, that certain necessary precautions are taken. With damped valves no departure from the true plane is observed for normal level. Beyond overload, a slight departure from the true plane is observed below 2,000 cycles; there is no departure above 2,000 cycles; it is noticeable again at the resonance frequency. In undamped valves the departure from the true plane is noticeable at ordinary levels, and becomes excessive at and around resonance. Careful observations seem to indicate definitely that the damping is particularly valuable in maintaining the ribbon in the true plane. There are also indications that no two valves behave identically in

this respect. This is to be expected because the symmetry of distribution of longitudinal stresses in the ribbon at the spacing springs depends largely on the surface conditions of the springs and of the edge of the ribbon.

The general arrangement of the metal bridge valve is shown in Fig. 9. The method of supporting and guiding the ribbon might prove interesting. The arrangement permits a very accurate sideward adjustment, and when the valve is properly set, the adjusting screws can be securely clamped. The correct height of the ribbon above the knife edge is obtained by a vertical adjustment permitted by a longitudinal slot through the bridge.

It might seem at first glance that too many adjustments are provided. But it must be readily admitted that it is far easier from a

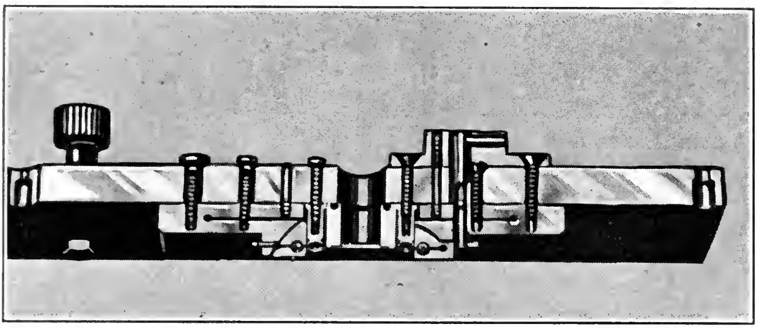


FIG. 10. Photograph of section of complete valve assembly.

mechanical standpoint to provide an adjustable bridge rather than to fit the bridges individually to each valve. The metal bridges are isolated from the frame, and connections from the bridge to the binding posts are made by means of heavy copper wire. One end of the ribbon is fastened to one bridge, and the other end to a vertical post which is pivoted to the other bridge and which carries a flat spring for tuning purposes. Small taper pins are used. The sectional photograph, Fig. 10, gives in correct scale the complete assembly. One of the most interesting features is that the length of the ribbon employed is very slightly in excess of the useful vibrating span. This represents a big saving, not in ribbon, to be sure, although four valves can be strung with the same amount of ribbon formerly used for one valve, but in electrical energy.

To be exact, the effective length of the ribbon, as part of the electrical circuit, is precisely the vibrating length, because the gold-plated adjusting screws form at all times a definite electrical contact, thereby short-circuiting the excess ribbon beyond this point. From the electrical circuit standpoint the length of ribbon is $^7/_8$ inch.

With a repeating coil suitably wound for this type of valve, the level required to produce overload is approximately 9 db. less than that required for the double ribbon type with 0.002 inch spacing. Therefore, satisfactory performance can be secured with an amplifier of moderate power, a point of great importance when considering portable equipment.

If, on the other hand, one chooses to make use of the standard recording channel set-up as it now exists, the above excess energy can be utilized for operating a valve of similar construction, but employing a very much stronger ribbon. Molybdenum seems to be a very happy substitute.

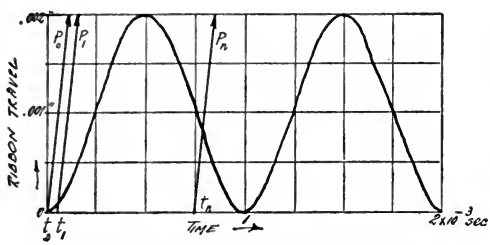
We have experimented with molybdenum ribbon and have found it entirely satisfactory. The tension necessary for tuning it is about one-fifth that required to break the ribbon. This gives an idea of the margin of safety available. The energy which a 9A, or bridging amplifier, is capable of delivering under any abnormal conditions is not sufficient to melt the ribbon. Approximately 1.25 amperes is the maximum current carried by the particular molybdenum ribbon with which we have been experimenting, before it melts. It can be heated to a cherry-red color without apparent ill effect. The expansion coefficient is about one-fourth that of duralumin. These figures readily prove that a valve equipped with molybdenum is a permanent valve in the strict sense of the word. This is quite important, especially when the sounds to be recorded include gun shots, such as we had, for instance, in the recording of *Big House.* Under such adverse conditions, it is generally found that duralumin becomes permanently deformed, increasing the response which, in turn, adds to the trouble. No such difficulty has been experienced with molybdenum. The critical limit of molybdenum is greater than the power limit of the bridging amplifier. No harm can therefore be done to the molybdenum valve by overloading the system.

The criticisms advanced against the single ribbon, short-length damped valve is that the presence of lumped resistance for damping contributes to the hysteresis, and that the effective exposure wave at

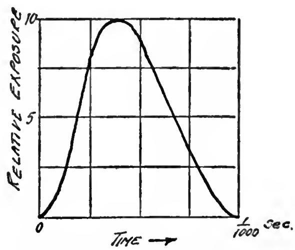
high frequencies is appreciably more distorted than in the case of the double ribbon valve.

With regard to the first criticism, we can say that although the argument may be sustained from a theoretical standpoint, practice has shown that no such thing exists, within the range of measurements, for properly adjusted valves.

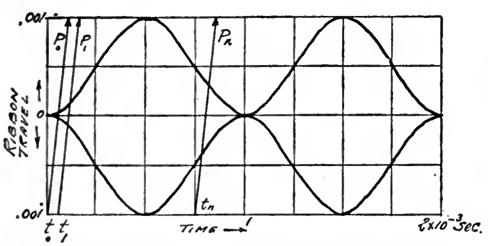
As to the second criticism, it is true that the shape of the exposure wave obtained with the single ribbon valve is different from that ob-



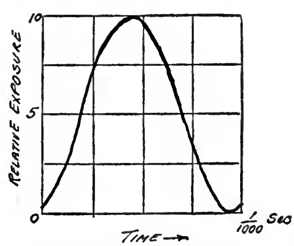
Single ribbon valve, 100 per cent light modulation, 1,000 cycles (or 2,000 cycles for 2:1 optical reduction)



Single ribbon resulting exposure



Double ribbon valve, 100 per cent light modulation, 1,000 cycles (or 2,000 cycles for 2:1 optical reduction)



Double ribbon resulting exposure

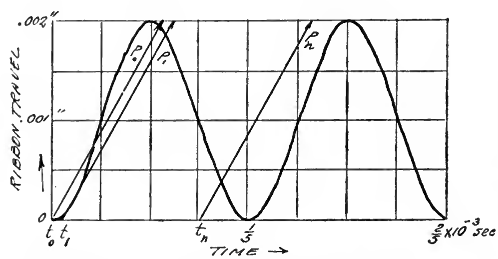
FIG. 11. Simple harmonic waves representing the position of the ribbon edges for different values of time; frequency 1,000 cycles per second.

tained with the double ribbon valve, but that the latter is better than the former one is an opinion hardly justified. Although the resulting transmission wave, as obtained from the positive film, is appreciably modified by diffusion and other phenomena of development, nevertheless it might be of interest to discuss the shape of the exposure wave on the negative in both cases.

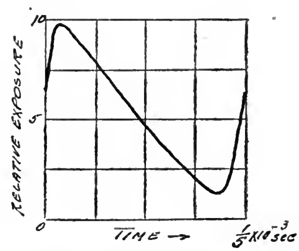
We can arrive at the result in three ways: by straightforward mathematical analysis; by applying the method of finite differences; and

graphically. The last method, the clearest one from a physical point of view, will be adopted. We will consider the extreme case of complete light modulation for 1,000, 5,000, and 10,000 cycles.

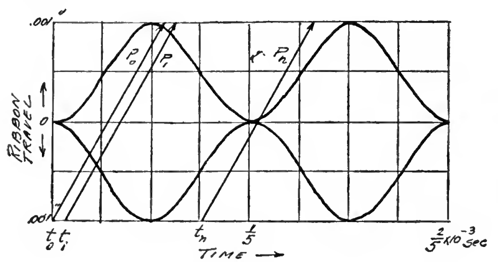
In Figs. 11, 12, and 13, the simple harmonic waves represent the positions of the ribbon edges for different values of time. The straight lines represent the space-time graph of certain points, P_o, $P_1 \ldots P_n$, on the film. For convenience it is assumed that events begin at time t_o when, in the case of the single ribbon valve, the edge of the ribbon



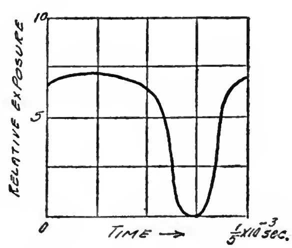
Single ribbon valve, 100 per cent light modulation, 5,000 cycles (or 10,000 cycles for 2:1 optical reduction)



Single ribbon resulting exposure



Double ribbon valve, 100 per cent light modulation, 5,000 cycles (or 10,000 cycles for 2:1 optical reduction)



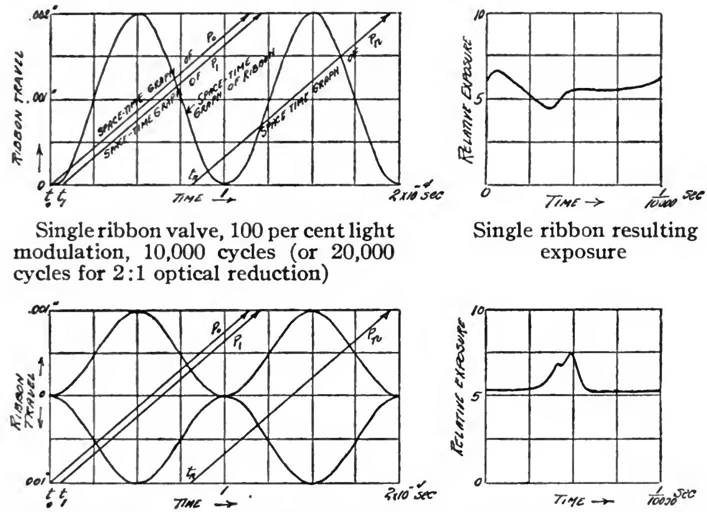
Double ribbon resulting exposure

FIG. 12. Same as Fig. 11; frequency 5,000 cycles per second.

just coincides with the knife edge, and with the double ribbon valve the ribbon edges are just about in contact with each other. The space-cycle intercept on the film is divided into equal parts, the beginning of each part being denoted by the points P_o, $P_1 \ldots P_n \ldots$. It is assumed that the point P_o on the film enters the light field at t_o. Evidently the time of exposure of each point is the projection of the space-time graph of the point not covered by the ribbons upon the time axis.

The resulting exposure wave in arbitrary units for the single and double ribbon valves is given in each figure.

In the case of the single ribbon valve the above-mentioned wave exposure at 1,000 cycles for 100 per cent modulation presents a theoretical 17 per cent second harmonic as compared with 3.5 per cent in the case of the double ribbon. At 5,000 cycles, conditions are appreciably reversed, as the double ribbon valve in this case has a theoretical second harmonic of 55 per cent, and the single ribbon 40 per cent. There must be a frequency between 1,000 and 5,000 cycles



Single ribbon valve, 100 per cent light modulation, 10,000 cycles (or 20,000 cycles for 2:1 optical reduction)

Single ribbon resulting exposure

Double ribbon valve, 100 per cent light modulation, 10,000 cycles (or 20,000 cycles for 2:1 optical reduction)

Double ribbon resulting exposure

FIG. 13. Same as Fig. 11; frequency 10,000 cycles per second.

for which the two types of valve have an equal theoretical amount of second harmonic. The amplitude of the fundamental is always greater for the single ribbon valve.

The above data are based on the consideration that the film actually perceives the same size of slit as formed by the ribbons, but as a matter of fact, an optical system is interposed between the valve and the film, and the scale of reduction produced by this system is in the ratio of approximately 2 to 1.

Effectively, this means doubling the nominal frequency as indicated in the curves shown above, or in other words, what we indicate as

1,000 cycles becomes 2,000 cycles; 5,000 cycles becomes 10,000 cycles, and so on. By this argument, we find that the second harmonic of the 1,000-cycle impressed wave, in the case of a single ribbon valve, is only of the order of 8 or 9 per cent, which checks exactly with actual measurements on positive film by means of electrical circuits. When the single ribbon valve begins to produce a second harmonic of serious amplitude the frequency of this harmonic is well beyond the useful frequency range, and the point that the single ribbon valve is not substantially inferior to the double ribbon valve is therefore justified. The 10,000-cycle exposure wave which, in effect, becomes 20,000 cycles when the optical reduction is taken into consideration, is given only as a curiosity.

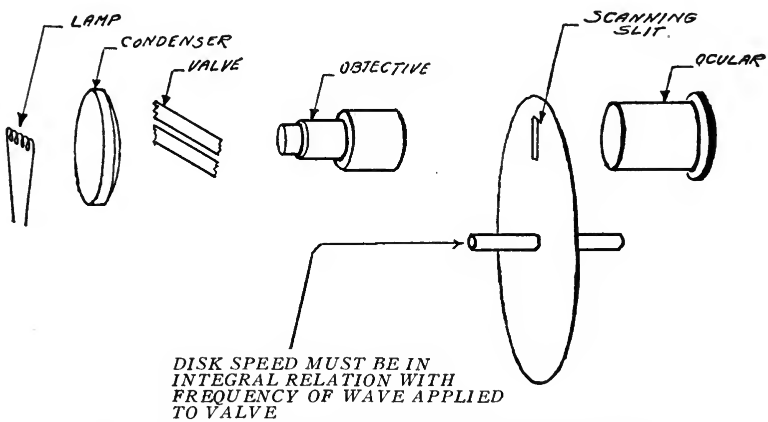


FIG 14. Schematic set-up of synchronous slit oscillograph.

The foregoing proves definitely that the advantages of the single ribbon light valve are chiefly mechanical, readily permitting the introduction of damping which, in turn, is desirable from the standpoint of over-all quality.

Over a period of a year, a large number of comparative records have been made with both types of valve, and invariably the single ribbon damped valve has proved superior from the standpoint of naturalness and pleasing quality, and we are satisfied with its performance beyond any doubt.

Incidentally, a certain percentage of the so-called high frequency film transfer loss should be definitely attributed to the light valve.

There are occasions when the exact overload point of a valve

must be known quite accurately. Such information is necessary for correctly setting the bias equipment for eliminating background noise. Also, a knowledge of the efficiency of the valve at various frequencies is quite often desirable, or a comparison between two types of valves might be a subject of fundamental importance.

All these questions can be immediately settled by the aid of the synchronous slit oscillograph. This device represents an application of well-known principles, and permits observing directly the behavior of a valve under exact working conditions without the aid of photoelectric cells, amplifiers, *etc.*, and at any frequency within the audio range. The schematic set-up is shown in Fig. 14.

For visual observations the scanning disk speed can be controlled by hand, and the wave can be held sufficiently stationary on the screen for all practical purposes. When a permanent photographic record is required, the speed of the scanning disk must be synchronized with the frequency exciting the valve. There are many ways of accomplishing this, which will not be described here.

This oscillograph is being used in our studio at present for routine work. When a new ribbon is fitted to a valve the spacing adjustment is carried out under the microscope in the usual way, the tuning is done by the absorption method as described on another occasion,[1] the damping is applied, and the efficiency is checked with the oscillograph. This procedure assures valves of extremely close adjustment, the deviation from the average being rarely in excess of ± 0.5 db.

The discussions and opinions outlined in this paper are the results of experience in recording sound on film at the Metro-Goldwyn-Mayer Studios over a period of time extending from September, 1928, to date. Whether or not these results have any resemblance to those obtained in other studios we do not know, nor is it an easy matter to find out.

In deciding upon changes in our recording technic we have always taken into consideration important economical factors in addition to quality, as we feel that quality must be achieved in the most economical manner in order to represent a real compromise. Obviously, in the matter of economics, the limitations of the reproducing apparatus in the theater field have been also taken into consideration.

It is also a fact that in this studio alone, twenty-five million dollars a year are placed at the mercy of the valve. We feel, therefore, justified in carrying out investigations of any nature, the results of which will assure a more uniform and more dependable product.

REFERENCE

[1] CECCARINI, O. O.: "The Measurement of Light Valve Resonance by the Absorption Method," *J. Soc. Mot. Pict. Eng.*, **XV** (July, 1930), No. 1, p. 60.

DISCUSSION

MR. SILENT: A single ribbon light valve having many similarities to the present day valves was developed by the Bell Telephone Laboratories in 1924 for the system of telephotography which is now in general use in this country.* For sound recording the double ribbon light valve was adopted in preference to the single ribbon valve after giving due consideration to the characteristics of both types. The relative amount of harmonic distortion introduced by the two light valves was a determining factor. Referring to Fig. 1 (of this discussion), the curves numbered 1, 2, and 3, represent the fundamental, second, and third harmonics, the "S" and "D" referring to single and double ribbon, respectively. It will be noted

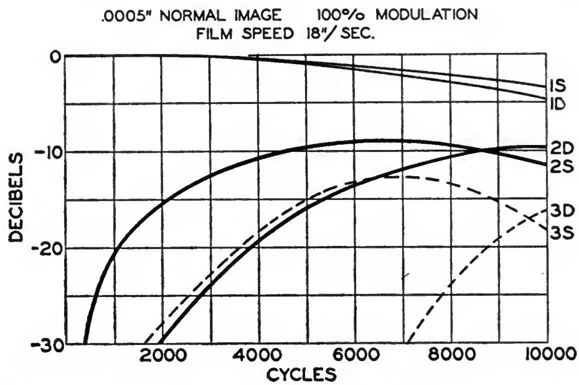


FIG. 1 (of discussion). Frequency components in exposure wave of single and double ribbon light valve.

that the amount of fundamental in the exposure wave drops off only about 1 db. for the single ribbon valve and 1.5 db. for the double ribbon valve at 6,000 cycles. However, the amount of harmonic distortion is considerably greater for the single ribbon light valve than for the double ribbon type at all points below about 9,000 cycles. Above this frequency harmonics are obviously of no importance. At around 1,000 to 2,000 cycles the second harmonic of the single ribbon valve is approximately 15 db. greater than that of the double ribbon valve. This represents approximately 25 times more distortion power in a record made with the single ribbon valve than in one made with the double ribbon type. The third harmonic of the single ribbon valve is also considerably greater than that of the double ribbon type. Practically, therefore, while we may safely say that neither type of light valve causes appreciable loss at high frequencies, the fidelity of the sound record produced by the double ribbon valve is considerably superior to that pro-

* IVES, H. E., HORTON, J. W., PARKER, R. D., AND CLARK, A. B.: "Transmission of Pictures over Telephone Lines," *Bell System Tech. J.*, **4** (April, 1925), No. 2.

duced by a valve with a single ribbon. The mathematics of the curves have been independently developed by a number of different investigators, but being rather lengthy, are omitted here. Although there is considerable in favor of the double ribbon valve from these considerations alone, other points are cited below.

A second reason why the double ribbon valve was chosen instead of the single ribbon valve concerns the power required to operate the valve. For a particular set of structural dimensions, it takes twice as much power to modulate a single ribbon valve as a double ribbon valve. This has a direct bearing on the development of portable equipment.

It is not ordinarily regarded as good practice to allow the light valve to clash, nor is valve clash an inaudible thing, but if a light valve inherently degrades the quality, the clash or overload will be less noticeable than if the system be of high quality throughout. With every effort being directed toward obtaining higher quality, no sacrifice can be acceptable which cancels these efforts. In analyzing actual sound records, visual inspection of the wave form is not only inadequate, but may be misleading. A badly overloaded record may not appear so by visual inspection. It is necessary to use a positive record and subject it to accurate quantitative analysis, since the negative bears a reciprocal relationship to the original wave form and is not used for reproduction in the theater.

While the light valve appears to be delicate when we consider some of its almost microscopic dimensions, it is a rather reliable piece of equipment, as is attested to by the millions of feet of sound film which have been produced by it, under any and all kinds of operating conditions, with relatively few failures. It is proving to be a surprisingly rugged piece of equipment. The use of various materials for the ribbon has been carefully studied. Using the constants given in Kent's *Handbook for Mechanical Engineers* for ribbons of duralumin and of molybdenum of the same cross-sectional area, it will be found that a light valve strung with duralumin can be tuned to a frequency 36 per cent higher than one strung with molybdenum, for the same factor of safety against breaking. In addition, the weight and resistance of the duralumin ribbon is inherently less than ribbons of other suitable materials, so that considerably less power is required for modulating. In the matter of the mechanical construction of the light valve, the fewer the adjustments necessary to apply to the valve, the better the construction the valve may be said to have. Obviously, it is not desirable to make extensive adjustments in the field if these can be eliminated by a little different mechanical design.

It sometimes appears that certain devices are developed independently of the laboratories' recognition of their need, when actually the laboratory anticipated the need and worked toward the provision of the device long before its appearance in the field. For instance, the need of higher tuning of the light valve was recognized by the laboratories in their original design, and the original light valve was tuned to a considerably higher frequency than 7,000 cycles. Regrettably, the strength of the light valve ribbon produced in quantity was inferior to that initially produced in small numbers. The tuning frequency, accordingly, had to be reduced. A shorter bridge light valve to correct this condition was brought into the field as soon as the necessary tests had fully proven it to be entirely satisfactory. The short bridge valve was generally adopted by the studios in both Hollywood and in the East and was found to be satisfactory. There have been

other improvements since, and more are being made. The gummed label valve was never approved because of its unsatisfactory performance.

The use of greases and oils intended for automobile lubrication cannot at present be regarded as satisfactory for the service of damping light valve ribbons. At best their contribution to the damping of the valve cannot offset the factor of uncertainty of action which they introduce. By properly tuning the valve to a frequency higher than any it is required to record there is no need for such damping. The apparent effects of peaked response of the valve below the tuning frequency are the results of harmonics of the oscillator which is used, and are not true phenomena of actual recording.

MR. CECCARINI: It is rather unfortunate that sturdiness and ruggedness are relative. A device might be considered quite sturdy until it fails many times during production, and causes the loss of thousands of dollars. To the mind of the operating engineer, such devices cease to be sturdy, and become potential sources of trouble, although the opinion of the laboratory engineer might remain unchanged.

Upon inquiring of our purchasing department, I find that since September, 1928, we have bought 5,000 feet of duralumin ribbon. Dividing this amount equally among 900 working days, it appears that an average of a little more than five valves per day have been strung. It seems hardly fair to call the light valve sturdy, on the basis of these figures.

The object of presenting the overload waves given in Fig. 7 of my paper is to show the action of the two types of valve under overload conditions, and for this purpose the negative transmission tells the story better than the positive.

It would be very convenient, indeed, to have a valve with all the adjustments made once for all, but unfortunately, the duralumin ribbon we have been getting has varied from 0.004 to 0.008 inch in width, and as long as these conditions exist we require adjustments, either in a crude form, or in the more precise fashion such as we have adopted.

With regard to the amount of second harmonic generated by the single ribbon as compared with the double ribbon valve, Mr. Silent states that the difference between the two is of the order of 15 db. for 1,000 cycles impressed fundamental at 100 per cent light modulation. While this figure coincides with mine, and appears correct in the abstract sense, it is nevertheless sadly misleading. It must be remembered that the amplitude of the second harmonic for the single ribbon valve, under the above conditions, is only of the order of 8 or 9 per cent of the fundamental. This is a negligible quantity, especially when considered as applying to 100 per cent light modulation, which in itself, is an extreme condition. It therefore makes no difference how much lower is the second harmonic of the double ribbon valve, be it 15, or 50, or 100 db. The argument has no logical value. The power required to overload a single ribbon valve is, correctly, twice as great as that required for the double ribbon valve. The undistorted power which our recording amplifiers are capable of delivering is many times greater than the overloading power of any one type of valves. The limit of the film characteristic coincides with the power limit of the valve, at least as far as the negative is concerned, and the thought that beyond this limit the amplifier still continues to deliver undistorted power, which might help, is a meager and costly consolation. It does not seem reasonable, from the standpoint of engineering economics to

make use of amplifiers of such excessive power capacity. In fact, some experiments which we conducted some time ago, with amplifiers having undistorted power capacity just slightly beyond that of the valve, have proved conclusively that they are of service under overload conditions, as they behave very much as power limiting devices, additional safeguards for the valve. After the wave shape is badly distorted by an overloading valve, very little, if any, additional distortion will be possibly introduced by an overloading amplifier.

In addition, the power limit of the amplifiers provided in the standard channel is set for disk recording, and certainly there is no objection to utilizing a larger proportion of this power, which would ordinarily be dissipated through an artificial line.

The molybdenum ribbon, which we have used and are using on special occasions, has proved to be much safer than the duralumin ribbon. Regarding the physical properties of a given metal or product, we always accept as correct the data furnished by the manufacturer. I can cite by the dozens, cases in which the duralumin valve broke, while the molybdenum valve never failed. Our contention is not that we have invented a single ribbon valve but rather that we have discovered in it valuable features, which, when properly taken advantage of, render it superior in practice to its double ribbon competitor.

Cup grease fulfills the purpose of damping very well. The fact that it serves also to lubricate machinery has no bearing on the subject. Its purpose is to damp mechanical vibrations, not to lubricate.

I would like again to emphasize the fact that the conclusions given in this paper were arrived at through a logical process of elimination, and that the experimental data were obtained over a long period of experimentation.

MR. SHEA: It seems to me that this is a question of overload. It does not matter what type of light modulating device is employed—whether a glow lamp, galvanometer, single ribbon or double ribbon valve. If it is overloaded, distortion will result. If, at high levels the light valve is subjected to reasonable overloads, I think it is a fairly rugged instrument. We have had light valves on laboratory test at 1,000 cycles with a continuous overload of 4 db. for as long as 1,000 hours.

MR. MILLER: There is a big difference between laboratory work and commercial production. The normal recording level is well below the valve overload point. Occasionally, however, an unanticipated peak must be accommodated, and overload is apt to occur. The commercial problem is to attain a compromise between level and quality. The level must be high enough for the theater equipment, and the recording should be without objectionable surface noise. For these reasons we must accept some overloads, up to the point where they, also, produce no objectionable distortion. Every foot of film we make involves this compromise.

MR. SHEA: If it is necessary in recording practice to meet these rather large overloads, you can retain the advantages of the double ribbon valve and get the advantages of the single ribbon valve by placing the two ribbons in different planes. This is done in the oscillagraph vibrator unit (the three-string valve) described at this afternoon's meeting, except that wires were used instead of ribbons.

MR. CECCARINI: In 1929 I made a valve such as Mr. Shea mentions, with the

two ribbons located in slightly different planes. This valve did not prove practical.

There seems to be a tendency to prove that it is not good practice to overload. I would like to call attention to some interesting facts published by Dr. Fletcher.* From the tables he gives we can readily deduce that if we were to record without any trace of overload, the average level of the record would be so low as to be of no commercial value. Obviously, we must strike a compromise by accepting a certain amount of overload. It is fair enough, then, to use a device which produces the least noticeable overload effect, and which has, in addition, an ample margin of safety.

MR. LAMBERT: In the matter of overload there is one phase which, I am afraid, Mr. Shea and Mr. Silent did not know about. We made a German version of *Big House*. One of the actors had a very weak voice, and his voice was recorded along with the noise of machine guns. In preparing this for release we used a certain maximum fader setting which was customary with our releases and which our experience of more than a year had shown should not be exceeded. That fader setting was about 2 or 3 fader steps higher than the average fader setting. In order to get the effect we wanted in *Big House* we had to overload the valve considerably; we tried all the valves we had, including double ribbon valves of 1 and 2 mil separation which had been previously used in recording the American version of *Big House* with success. But on this one we broke all the double ribbon valves and all the single ribbon valves that had duralum in ribbons. The overloading due to the gun shot was required in order to force the dialog up to where we needed it. The overload point of the valve was +4 db., and the indicated levels in the valve on this recording were as high as +26 db. The only valve which withstood this treatment was strung with a single molybdenum ribbon. During this recording we broke one ribbon and melted another, but obtained the record.

* FLETCHER, H.: "Some Physical Characteristics of Speech and Music," *Reviews of Modern Physics*, **3**, No. 2, p. 258.

A SOUND FILM RE-RECORDING MACHINE*

J. J. KUHN**

Summary.—*In sound picture production, the process of making the release print negative for sound requires the reproduction of the existing positive sound record in order that it may be recorded in proper continuity and corrected for volume level. The machine used for this purpose is called a "re-recording machine."*

This paper describes a new re-recording machine recently made available which is suitable for use in studios using either the variable density or variable width method of recording sound. The machine described employs a novel type of film aperture and a new method of focusing the sound lamp. To insure uniformity of film movement and to eliminate unwanted noises in the re-recording process, the workmanship must be of the highest order. Some of the requirements and testing methods employed in the manufacture of the machine are discussed.

The first synchronous talking pictures produced were comparatively short subjects. They consisted of one or two reels which were built up of scenes or takes each of which was complete in itself. Consequently, it was then only necessary to patch such pieces of film together in order to obtain a complete picture. Pictures obtained in this manner, of course, had many limitations and except for their novelty as talking pictures could not have been considered box-office attractions. The motion picture industry was, furthermore, too progressive to remain satisfied with such a product.

As a result of the continued efforts of picture producers and of manufacturers of sound picture recording apparatus, the recording of sound to accompany pictures, as now produced, involves many practices which were formerly found effective in producing silent pictures. The most prominent of these is probably that employed in trick photography—duping—which in sound work has its counterpart under the title "dubbing." As noted previously in this JOURNAL,[1] dubbing may be simply the making of a sound record with the microphone to match a picture; it may be the combining of sounds picked up by the microphone with one or more sound records already

* Presented in the Symposium on Sound Recording at the Spring, 1931, Meeting at Hollywood, Calif.

** Bell Telephone Laboratories, New York, N. Y.

made; it may be the combining of sound records only; or it may be simply re-recording an existing record. The last-mentioned has three principal purposes:

(1) To make a new master record.
(2) To transfer a record from film to disk or *vice versa*.
(3) To correct volume variations and other sound effects.

It is with respect to the machinery employed in reproducing sound film for the purpose of combining or re-recording sound records on film that this paper is concerned.

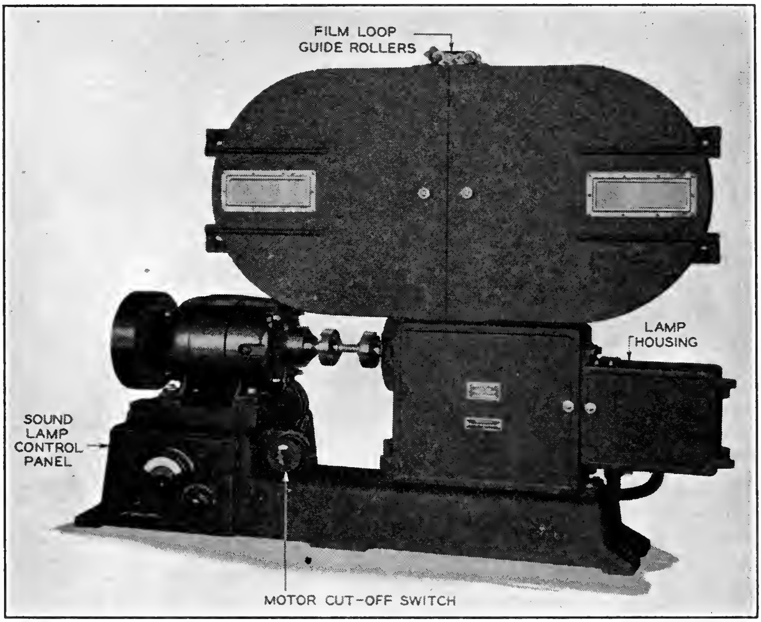


FIG. 1. Front view of re-recording machine.

Some of the requirements that a re-recording machine should be capable of fulfilling are: (*a*) the reproduction of a sound record on film should be a true copy of that record, and should not include additional background noise; (*b*) the film should move past the scanning light beam at a uniform speed, *i. e.*, without flutter of the high-frequency or low-frequency type, usually referred to as "wow-wows;" (*c*) there should be no tendency for emulsion or wax from the film to deposit on the film gates or guides; (*d*) noise from the rotating parts

of the machine or vibration of the building should not be picked up by the speech circuit; and (*e*) the machine should be easy to thread, operate, and maintain.

During the past year the Western Electric Company has made available to producers a re-recording machine which fulfills these requirements in a practical sense, and which includes a number of novel features. The front view of this machine is shown in Fig. 1

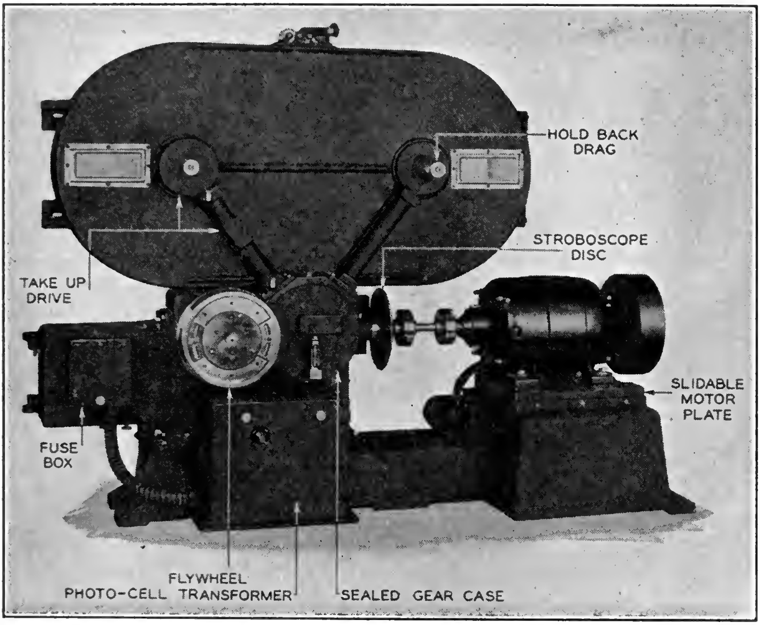


FIG. 2. Rear view of re-recording machine.

and the rear view in Fig. 2. It consists of a cast base upon which are mounted:

(*a*) a sound reproducing head and magazine;
(*b*) photoelectric cell coupling transformer; and
(*c*) the driving motor.

A panel for controlling and indicating the current through the sound lamp is mounted in the base.

Sound Reproducing Head.—The reproducing head consists essentially of a double-faced housing, the central partition of which provides a common support for all associated units. This construction

makes it possible to obtain a very rugged but easily accessible assembly. The housing at the front is the reproducing compartment, and the one to the rear is the gear case.

Reproducing Compartment.—Fig. 3 is a front view of the machine with the various compartments open to view. The drive shaft from the motor enters the rear of the case and drives two sprockets through suitable gearing. One of these sprockets is a combination pull-down and hold-back sprocket, and the other is the sound sprocket. These

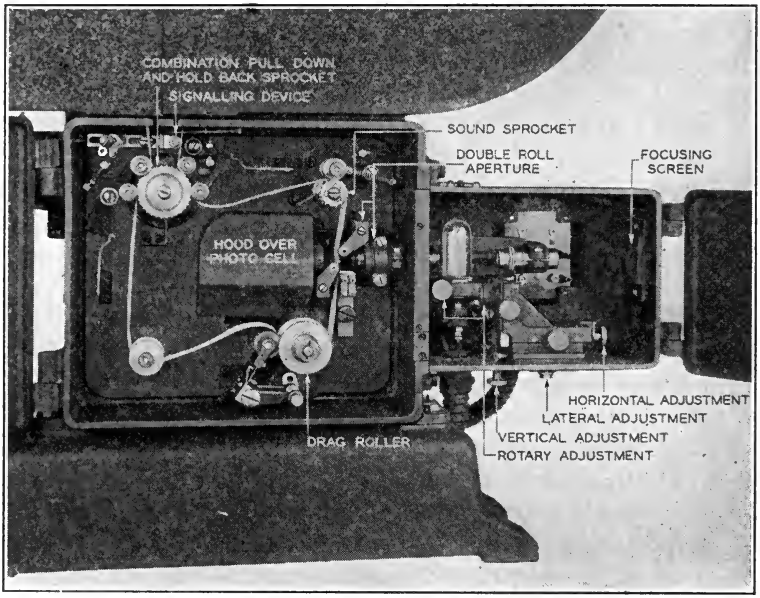


FIG. 3. Reproducing and lamp compartment.

are the only two members inside the film compartment that are positively driven.

The film magazine is located directly above the reproducing compartment. The left-hand half of the magazine contains the supply reel and the right-hand half the take-up reel. The magazine is of sufficient size to accommodate either 1,000- or 2,000-foot film reels. Ample finger space is provided around the reels to simplify threading. The units are of cast aluminum rigidly bolted in place. The shaft supporting the supply reel operates against a friction drag which is adjustable at the rear of the magazine. The take-up reel is rotated by means of a friction drive geared to the motor shaft.

In the process of dubbing, it is frequently necessary to add noise effects or other sounds already recorded on a film. Where noise effects are of a more or less indiscriminate type, such as the clatter of horses' hoofs, wind noise, machine-gun fire, *etc.*, they are usually recorded on short lengths of film, the ends of which are cemented together to form an endless loop. To accommodate such loops in the re-recording machine, a set of guide rollers is provided on top of the film magazine.

Film Passage.—The film coming from the supply reel is held in engagement with the pull-down sprocket by a double pressure roller. It then passes around an idler roller to a large drag roller.

The film then passes upward through a roller type of sound aperture to the sound sprocket, thence to the combination pull-down and hold-back sprocket. On leaving the hold-back sprocket the film passes by a roller which is associated with a signaling device and onto the take-up reel in the film magazine. Excluding the pressure roller, all sprockets, guide-rollers, *etc.*, in contact with the film are constructed of stainless steel.

The roller type of sound aperture guides the film past the scanning lens which projects the image of a brightly illuminated slit upon it, the variations in the transmission of the film causing variations of the current through the photoelectric cell mounted behind it in accordance with the pattern on the sound track.

Light for illuminating the slit of the lens system is obtained from a special ribbon filament lamp mounted in an adjustable holder.

Drag Roller.—The purpose of the drag roller is to impart a uniform tension to the portion of the film between the drag roller and the sound sprocket. It is constructed of stainless steel and is approximately $1^3/_4$ inches in diameter. Since the uniformity of the tension is determined by the constancy of rotation of the drag roller, it is important that the latter run absolutely true. Flanges are provided on each side of the roller to guide the film through the sound aperture.

The drag roller is prevented from rotating freely by friction disks placed against the sides of the roller. These consist of a special alloy of bronze and graphite. The drag can be varied by adjusting the pressure of the compression spring on the outer face of the drag roller.

The film is held against the drag roller by means of a pressure roller. This roller is constructed of impregnated fabric, and is held under constant tension by means of a flat steel spring.

Double Roller Aperture.—As previously noted, the film between the drag roller and sound sprocket is held under tension while the machine is operating. To insure that the film remains in focus, at the same time applying as little pressure as possible against its face, rollers are

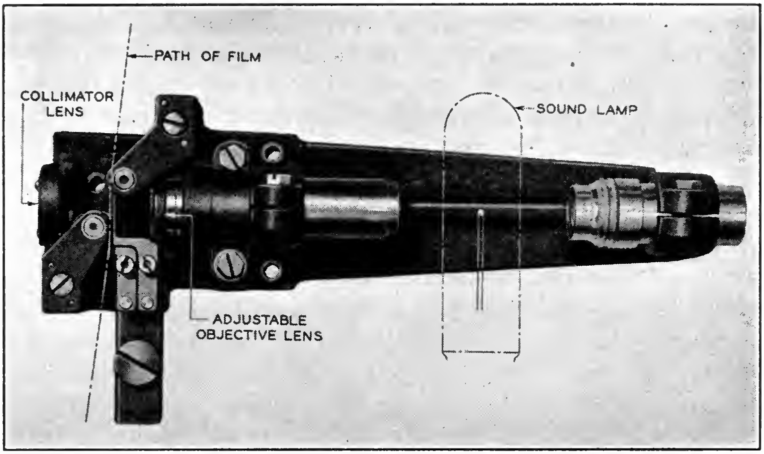


FIG. 4. Double roller aperture.

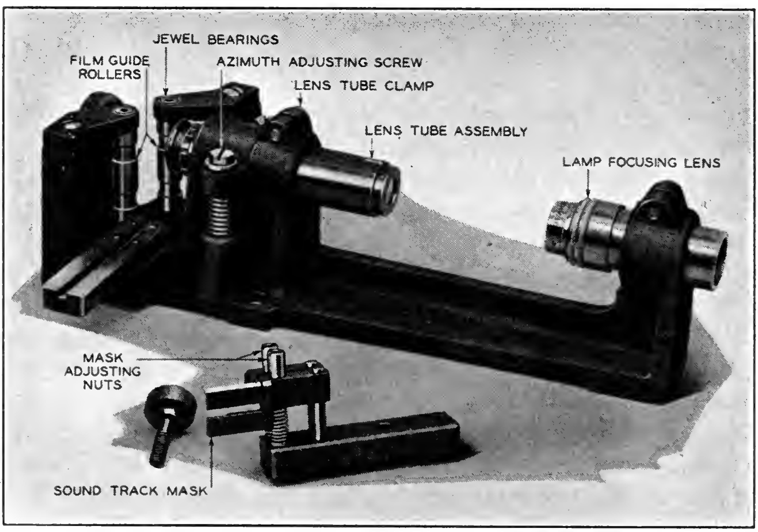


FIG. 5. Double roller aperture, side view.

placed in contact with the film at points directly above and directly below the scanning beam. The upper roller bears against the emulsion side of the film, while the lower roller bears against the base. This arrangement is clearly illustrated by Fig. 4, which also shows the location of the lamp with respect to the aperture lens unit and the focusing lens. A side view of the double roller aperture assembly is shown in Fig. 5. The rollers are made of stainless steel and rotate in jewel bearings. These are ground very accurately with respect to their bearing surfaces so that they will rotate freely without displacing the film. The bearing brackets supporting the jewelled rollers are dowelled in place so that they can be removed for inspection and cleaning should this be found necessary.

In Fig. 5, the sound track mask has been removed to show its general construction. This mask is provided so as to permit the beam of light to project only over the area of the sound track which it is desired to scan. This area can be equivalent to the full width of the sound track or can be adjusted so that only a portion of the sound track is scanned.

Rollers are employed on each side of the film rather than two rollers against the base side, as it was found that the latter arrangement required greater tension on the film to hold it in the focal plane.

A further advantage of the staggered rollers is that variations in the position of the film with respect to either of the rollers cause less movement of the film from its focal plane. For example, variations in the stiffness of the film cause it to pass over the rollers at a slightly varying radius. The staggered roller arrangement equalizes such variations, whereas, with two rollers on the same side the film will go out of focus to a rather large extent. Measurements on sample films in a test fixture under conditions approximating those employed in the re-recording machine show a very slight movement of the film from its focal plane when the film is maintained under the proper tension. This movement, incidentally, is of the order of the thickness of the emulsion and is not sufficient to cause noticeable variation in the sound output.

Optical System.—The aperture assembly provides a rigid mounting for the lens assemblies. The center one—the aperture lens unit—is a combination of condensing lens, slit, and the objective lens employed for focusing the scanning beam upon the moving film. A collective lens at the extreme left is provided for insuring that the light projected

through the film falls on the active elements of the photoelectric cell. A third lens, shown at the extreme right, focuses an image of the lamp filament onto a ground glass cross-line screen and assists in simplifying lamp adjustments. A schematic arrangement of the optical system is illustrated by Fig. 6.

The lamp employed is a 6-volt, 9-ampere ribbon filament lamp. The condensing lens in the aperture lens unit has a magnification of

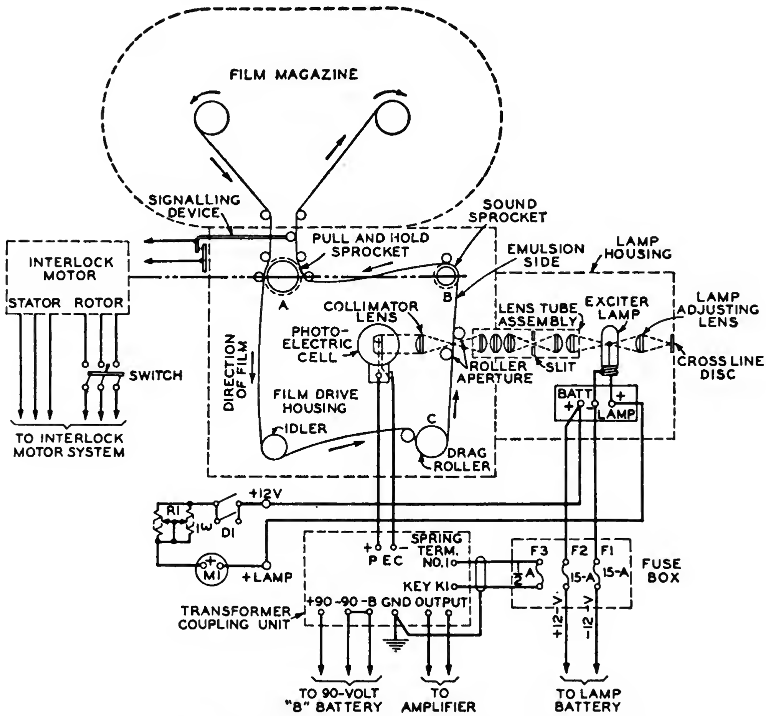


FIG. 6. Schematic arrangement of re-recording machine.

unity and focuses the image of the filament onto a mechanical slit, flooding it with an intense light. The opening in this slit is held to a separation of maximum 0.0012, minimum 0.0009 inch. It is centrally located on the optical axis of the condensing and objective lenses, and the edges forming this slit are selected for smoothness and parallelism throughout their entire length.

The objective lens is designed to give a 1.5 to 1 reduction of the slit, resulting in an image at the film plane 0.0007 ± 0.0001 inch wide.

In designing the lens system special care has been taken to provide an image that is uniformly illuminated throughout its length, and with clearly defined edges and a field free from flare. All lens assemblies are inspected for accuracy and quality.

The objective lens is adjustable to permit focusing of the unit. Movement of the lens unit is obtained by rotating the knurled head and locking it in place by a special lock nut. The lens unit is held in a rigid mounting having a double bearing, one of which is slotted to permit clamping the unit in place. Between the double bearing is a rotating collar which surrounds the lens unit, and provides a means for adjusting for azimuth.

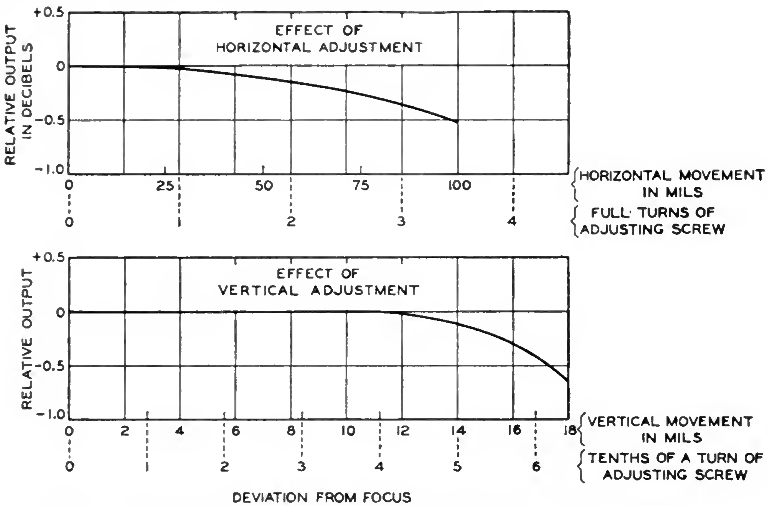


Fig. 7. Effect of adjustment of exciting lamp on volume output of reproduction.

The collimator lens is a small lens provided for insuring that the maximum amount of light transmitted through the film will be projected to the sensitive portion of the photoelectric cell. At the right of the illuminating lamp, a separate lens unit is provided for projecting an image of the lamp filament upon a ground glass screen located in the side wall of the lamp housing, thereby simplifying the adjustment and replacement of lamps in the field. When the system is first set up, the various units are adjusted with the aid of specially selected single-frequency films. The output of the photoelectric cell is connected to a suitable amplifier and volume indicator so that variations of response at different frequencies can readily be measured.

The lens and lamp are adjusted to give the smallest difference in the scanning loss between the reproduction of a 1,000-cycle recording and that of a 7,000-cycle recording. A loss of approximately 1 db. is introduced for a 0.0007-inch scanning image and is due to the finite width of the scanning beam.[2] When these adjustments are accurately made, the lamp adjusting lens is then focused so as to project a sharp image of the lamp filament on the ground glass screen. The vertical and horizontal positions of the ground glass screen are then adjusted so that the cross-lines on this screen coincide with the center lines of the lamp filament. To adjust subsequent lamps it is only necessary to center the image of the lamp filament on the cross-line. This lamp adjusting lens system also shows when the lamp filament sags, thus indicating need for replacement.

Lamp Adjustment.—The sound lamp is provided with adjustments in all directions. This permits the attendant to obtain the best pos-

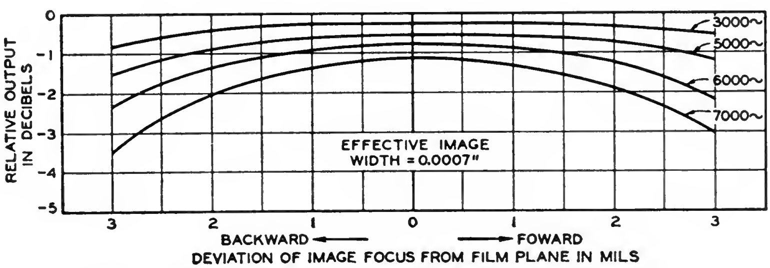


FIG. 8. Focus of objective lens *vs.* quality of reproduction.

sible results from his equipment. Contrary to the normal expectation, however, the adjustment of the lamp is not as critical, in so far as quality of reproduction is concerned, as it may appear. As is illustrated in Fig. 7A, an out-of-focus condition of the lamp approximating 100 mils from the ideal horizontal position, or about $3^1/_2$ turns of the adjusting screw, results in a loss of light projected on the film equivalent to 0.5 db. in volume. It is evident that the permissible variation of the horizontal adjustment of the lamp is greater than would ever be required. Fig. 7B shows a similar chart for vertical adjustment. Here a deviation of 18 mils, or $^5/_8$ of a turn from normal, will result in a loss of about 0.6 db. When it is considered that the width of the lamp filament is over 30 times that of the mechanical slit to which it is adjusted, there should be no difficulty in adjusting the lamp in a comparatively short time.

An out-of-focus condition of the lamp affects the volume output—a similar condition in the position of the objective lens affects the frequency response obtained through the film. As noted in Fig. 8, a change in the adjustment of the objective lens from its theoretically correct position introduces a scanning loss in reproduction which

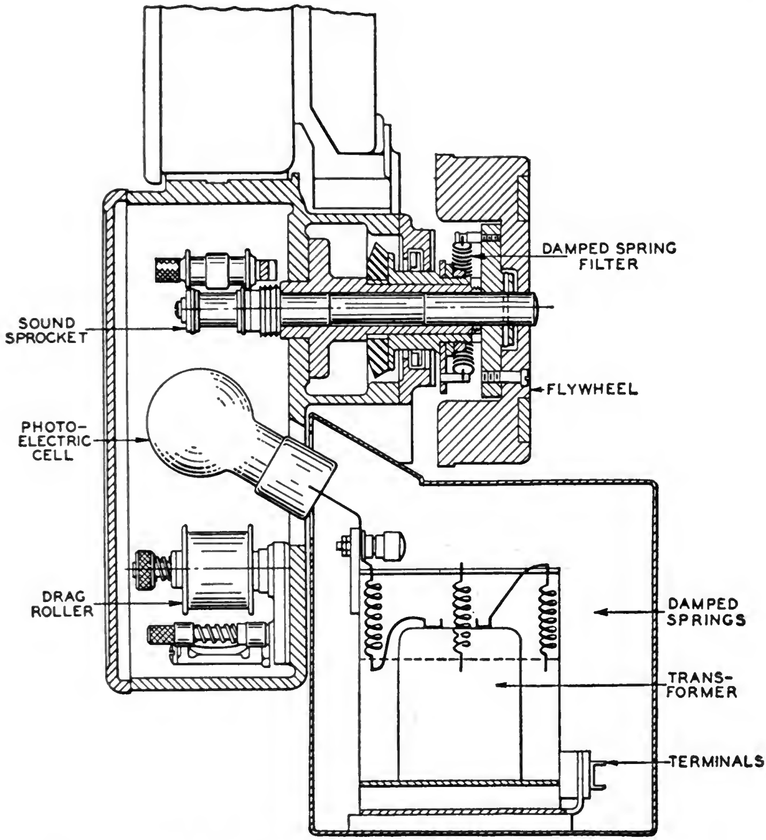


FIG. 9. Cross-section of photoelectric cell and coupling transformer.

varies with frequency. A variation of the position of the objective lens of one mil from the normal reduces the response at 7,000 cycles by only a fraction of a decibel. Since this lens is adjusted by the electrical method previously described it is not difficult to set the lens at its optimum position. If both the objective lens and the lamp are out of focus the total loss in decibels is the sum of the two losses.

Photoelectric Cell and Transformer.—The photoelectric cell is mounted in line with the collective lens and in such a position that the terminals of the cell are directly adjacent to the terminals of the transformer mounted directly in back of it. A cross-sectional view of the machine illustrating these units is shown in Fig. 9.

The transformer has an impedance ratio of about 625 to 1, and was selected because it is as high as is considered desirable for reproducing a frequency band 10,000 cycles wide. The transformer is mounted in a cradle suspended on damped springs. This arrangement insures that vibrations either from the machine or from other sources in the building are not transmitted to the transformer and cannot,

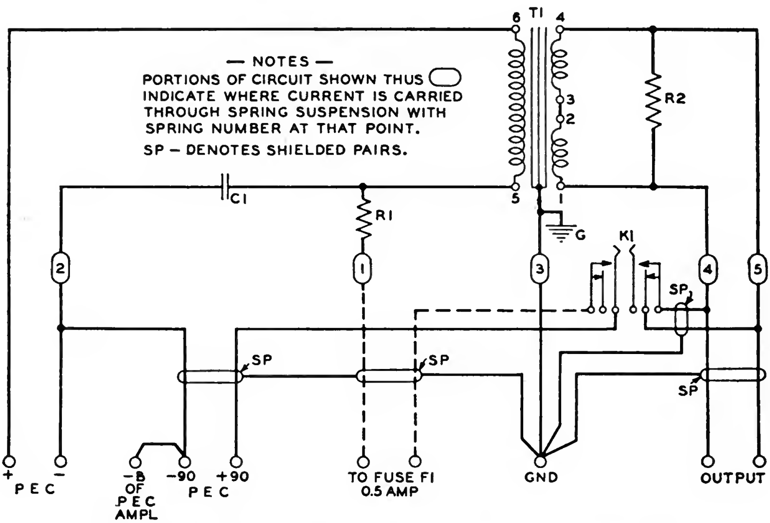


FIG. 10. Schematic diagram of coupling transformer circuit.

therefore, introduce noise into the recording circuit. The transformer unit is provided with a key by means of which the polarizing potential of the photoelectric cell can be cut off. The circuit arrangement of the coupling transformer is illustrated in Fig. 10. The resistance, R_1 serves as a protection for the polarizing voltage supply in case the terminals or elements of the photoelectric cell should become short-circuited and in conjunction with the condenser, C_1, filters out noise originating in the polarizing potential source. The resistance across the low side of the transformer stabilizes the impedance of the photoelectric cell output circuit.

Excluding the scanning loss, the frequency response of the reproducing system, measured with a modulated light beam falling on the photoelectric cell, does not vary more than 1 db. at the output terminals for frequencies varying from 50 to 7,000 cycles. From 7,000 cycles up, the characteristic rises slightly, reaching +2 db. at 10,000 cycles.

The relative output of the reproducing system using a lamp current of 9 amperes and a suitable amplifier is as follows:

		Relative Output Level in Db.
(*a*)	1,000 cycles, film transmission 30 per cent	0
(*b*)	unmodulated sound track	−34
(*c*)	photoelectric cell illuminated by sound lamp through a clear part of stationary film but with machine running	−57
(*d*)	photoelectric cell dark, machine not running	−62

It is evident from this data that the machine is capable of reproducing films having a volume range of 57 db., a value greatly in excess of present-day practices.

Driving Motor.—The rear view of the machine, shown in Fig. 11, discloses a 1/4-hp., 1,200-rpm., 220-volt, 60-cycle interlocked driving motor, supported and cushioned on an adjustable plate. This plate is dovetailed in the bed of the re-recorder base so as to permit the endwise withdrawal of the motor and the re-assembling of it without having to readjust it on its sub-base. In this way the motor driving shaft can be lined up with the corresponding shaft on the reproducing head by means of a tubular alignment sleeve, and the motor can be withdrawn to permit the insertion of the flexible couplings. These couplings are torsionally rigid but are flexible in a direction parallel to the shaft, thereby permitting a certain amount of end-play in the armature without transmitting this disturbance to the reproducing head. A switch is located on the base so that the motor can be shut off independently of the system when the film in its magazine has been completely reproduced.

Gear Case.—The shaft attached to the motor is provided with a stroboscope disk having 36 slots. The shaft then enters the gear case which contains the gearing necessary to reduce the motor speed of 1,200 rpm. to a speed of 360 rpm. at the sound sprocket and its filtered flywheel, and 180 rpm. at the combination pull-down and hold-back sprocket. Gearing is also provided to drive the take-up mechanism at the back of the film magazine.

In order to insure a minimum of noise and vibration in the machine and that the film is propelled at a constant rate, it is necessary that all gears, sprockets, bearings, and their associated shafts be constructed accurately. The entire gear housing is sealed against the leakage of oil. A gauge is provided so that the oil may be maintained at the proper level.

Flywheel and Filter.—As previously noted, the flywheel associated with the sound sprocket is provided with a filter. The filter used is of the spring type, suitably damped. The flywheel is statically

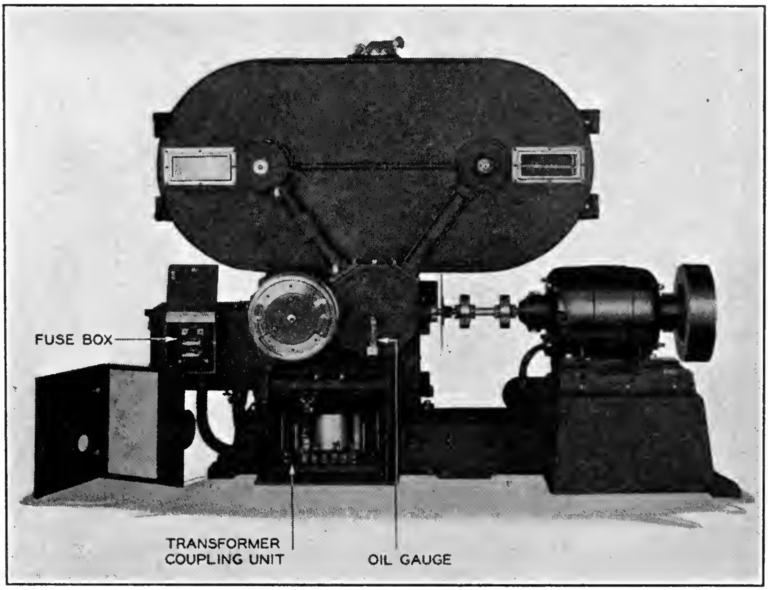


FIG. 11. Rear view of re-recording machine.

balanced in the factory and is again balanced after the entire machine is assembled. In this operation, the counterweights on the outer face of the flywheel are fastened in the required position so as to obtain the optimum balance of the entire assembly. The position of the counterweights is definitely indicated so that if they are at any time removed, they can be replaced in the correct location.

The rim of the flywheel is graduated into 120 divisions, and the motor shaft is equipped with a shutter having 36 slots. The combination of these two units comprises a very accurate stroboscope which

enables the recorder attendant to obtain a quick check as to whether the flywheel is rotating uniformly.

In the testing of re-recording machines before leaving the factory, the uniformity of flywheel rotation is accurately checked against that of the stroboscope disk by a special microscope checking fixture. Because of the over-all requirements imposed, it is necessary that the spacing of the slots in the stroboscope disk and the lines on the face of the flywheel be extremely uniform. This spacing is done on special

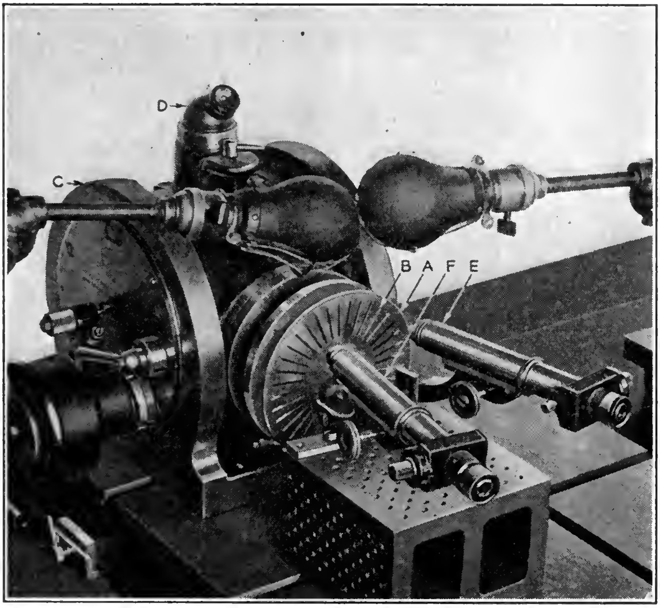


FIG. 12. Fixture for checking spacing of slots in stroboscope disk.

machinery developed for the purpose and is checked on special fixtures such as are illustrated by Fig. 12 and Fig. 13.

The stroboscope disk, *A*, is mounted on the shaft of a Carl Zeiss dividing head, *C*. Microscope, *E*, is adjusted so that its main hairline coincides with one edge of the slot, *B*, appearing in the optical field. Microscope, *F*, is similarly adjusted and focused on the corresponding edge of the next slot. The angular reading in the eyescope, *D*, is noted and it is then indexed as 10 degrees. This operation brings a new slot into the field of each microscope and since the latter are calibrated in tenths-of-thousandths of an inch, the variation of

spacing from the initial settings can be very accurately measured. As each new pair of slots is indexed the variation from the preceding set is noted and the final over-all error is computed. This total error is held within 0.001 inch for the 36 slots. A similar procedure is followed for checking the spacing of the slots in the flywheel (Fig. 13).

These extraordinary efforts to obtain accuracy, while costly, are

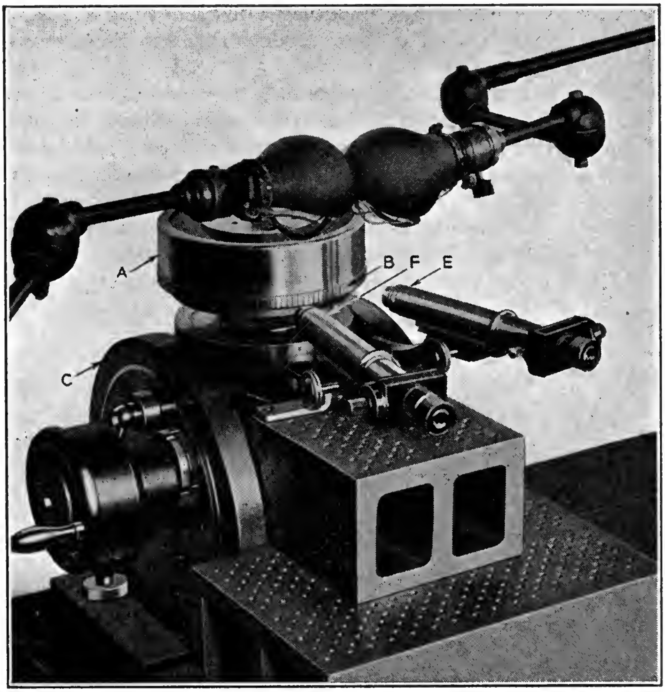


FIG. 13. Fixture for checking spacing of divisions on face of flywheel.

made to insure that all machines sent to the field will provide the high grade of service expected of them. Furthermore, the performance of the re-recording machines now in use at various studios amply justifies these efforts. In addition to fulfilling the basic requirements noted in the first part of this paper, the recording personnel finds that very little time is required to thread the film and set the machine into operation.

REFERENCES

[1] MORGAN, K. F.: "Scoring, Synchronizing, and Re-recording Sound Pictures," *Trans. Soc. Mot. Pict. Eng.* (1929), No. 38, pp. 268–88.

[2] STRYKER, N. R.: "Scanning Losses in Reproduction," *J. Soc. Mot. Pict. Eng.*, **XV** (Nov., 1930), No. 5, p. 610.

DISCUSSION

MR. TOWNSEND: In most reproducing machines a fairly wide slit is used with a high reduction, the slit width being obtained by means of an optical system. Why in this particular case was it found better to use a small slit and a small optical reduction in the objective lens, in order to secure a light beam at the film 1 mil wide?

MR. DAILY: The Bell Telephone Laboratories have made a thorough study of the efficiencies of various types of optical systems, and while I do not have at hand the comparative figures on this lens assembly as compared with others, I think it is as efficient as any available. A one mil slit is used between the condensing and objective lenses with a 1.5 to 1 reduction in image width through the objective lens. Such a system has been found to be very satisfactory, giving a light field on the film of sufficient intensity and free from flare.

MOTION PICTURE SCREENS—THEIR SELECTION AND USE FOR BEST PICTURE PRESENTATION*

FRANCIS M. FALGE**

Summary.—*Motion picture screens contribute very materially toward the success of a picture. A poorly selected or poorly used screen will detract considerably from pictures on which huge sums of money are spent. A good screen surface costs little, but its importance is beyond all comparison with its cost. This paper deals with the selection and use of screens for assuring good projected pictures.*

Picture presentation, especially since the advent of sound, is fraught with many difficulties, and the screen is by no means the least of these. The overcoming of all other difficulties—the light source, the film, the lenses, *etc.*—may all be for naught if the last one, the screen, should interfere. But the exhibitor often little realizes the importance of the screen. His projectionists take care of all other equipment, but even they allow a dirty or imperfect screen to pass without comment. This not only means a loss of efficiency, but a loss at the box-office as well, because of dissatisfied patrons. The objective of every exhibitor, therefore, should be to keep his screen in as good condition as possible at all times.

When selecting a screen the following points, which will be discussed individually, should be considered:

(1) Adaptability to the particular theater;
(2) Reflective efficiency;
(3) Sound characteristics;
(4) Durability;
(5) Uniformity;
(6) Fireproofing;
(7) Illusion of depth;
(8) Adaptability to color;
(9) Size of screen required.

(1) ADAPTABILITY TO THE PARTICULAR THEATER

There are many kinds of screens, but all come within three general classifications. There is no screen made today which is an average

* Presented in the Symposium on Theater Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** Beaded Screen Corp., New York, N. Y.

type best suited to all houses. For that reason, screens should be selected which fit the characteristics of the particular house, bearing in mind the fact that theaters have very dissimilar characteristics. They may vary in width from 20 to 120 feet or more, and in length from 50 to 150 feet. They may have no balcony or they may have three; the angle of projection may be zero or it may be 35 degrees, and the screen may be from 10 to 30 feet from the front row of seats.

Types of Screens

There are three general types of screens:

(*a*) Diffusive or matte
(*b*) Reflective or metallic
(*c*) Directive or beaded

All three types of screens are made with openings to permit the passage of sound.

Fortunately, screen characteristics are so definite that consideration of the vital principles of each of these types should permit a ready decision as to the screen best suited to a particular house.

Practice seems to bear out the fact that a matte screen which radiates equally in all directions appears less brilliant the farther away the observer is from it. This may be due to the loss of light through the atmosphere, a smaller included angle of light, and the interference of light sources in the house. These factors in general tend to make the screen too brilliant for those in the front rows of seats, and not sufficiently brilliant for those in the rear seats. When selecting a screen, consideration should be given to these points.

(*a*) *The Diffusive Screen.*—Diffusive screens are made of cellulose coated materials; rubberized fabrics; closely woven treated materials; coarsely woven materials with or without metallic fibers; woven materials with irregular glass particles; and coated metals. The distribution of light from a typical diffusive screen is shown in Fig. 1. The curve including the largest area, indicating the largest reflection values, is, in general, the best.

The advantages of diffusive screens may be listed as follows:

(1) They redirect a large percentage of light—*i. e.*, they are very efficient;
(2) They are good for color picture projection—*i. e.*, they are not color-selective;
(3) They redirect light through wide angles, giving satisfactory projection for wide theaters or for theaters with steep projection angles.

(*b*) *The Reflective Screen.*—Reflective screens are made of aluminum and other polished and coated materials, and have varying degrees of diffusiveness.

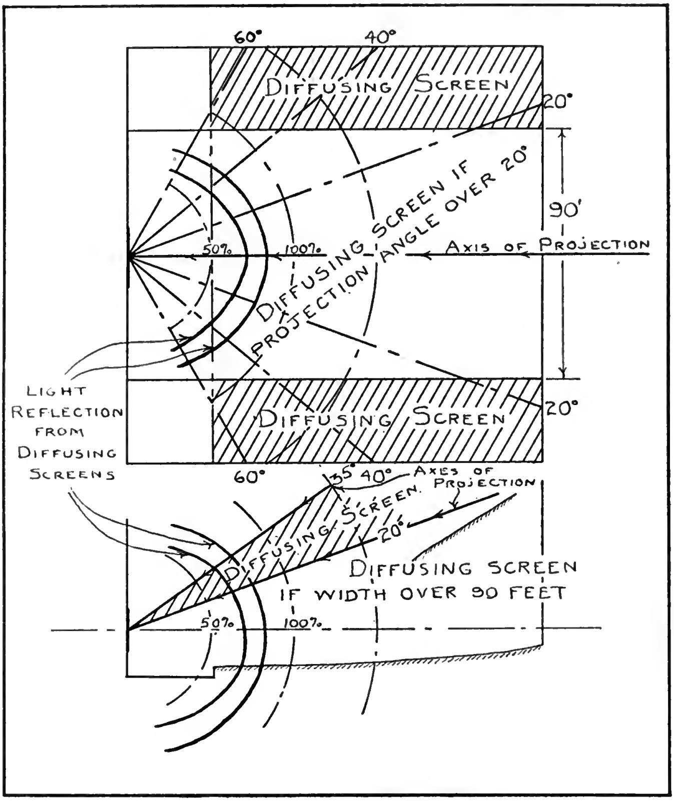


FIG. 1. Characteristics of diffusive screens.

Their advantages may be listed as follows:

(1) They build up the intensity of the reflected light so that under certain conditions they add to the apparent brilliancy as viewed from the rear seats;

(2) Their use results in economies in projection in houses which have large ratios of length to breadth.

The disadvantages of reflective screens are:

(1) They are not desirable where the angles of projection are greater than 10 degrees;

(2) They can be used in relatively few houses;

(3) They are not satisfactory for the projection of colored pictures—*i. e.,* they are color-selective.

We may conclude, therefore, that reflective screens are useful for few houses because of prevalent conditions and their limited reflection angles. Also, they are not good for color picture projection.

(*c*) *The Directive Screen.*—Directive screens are diffusing screens on which are imbedded glass globules; they are also called "beaded

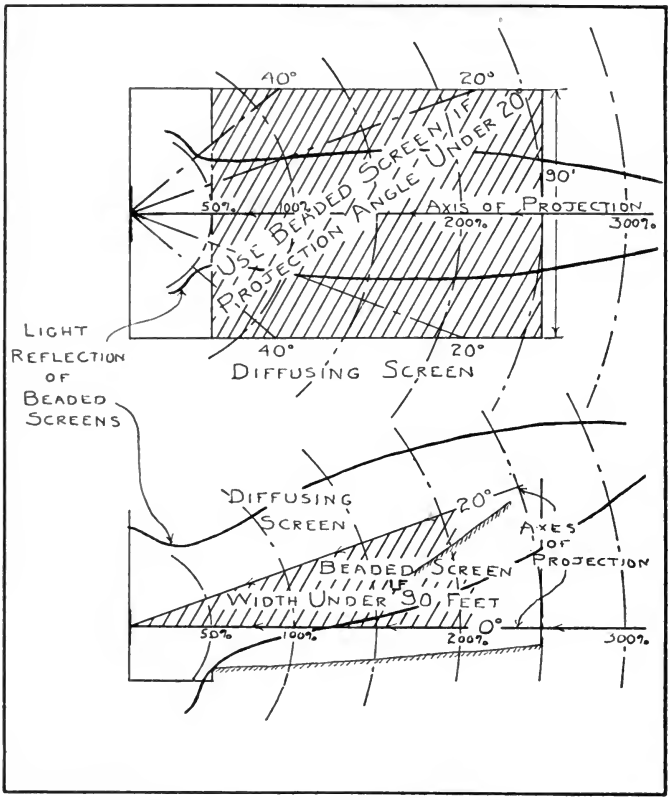


FIG. 2. Characteristics of beaded screens.

screens." The distribution of light from such a screen is shown in Fig. 2.

Their advantages may be listed as follows:

(1) They build up the intensity of the reflected light so that a more brilliant picture can be seen from the rear seats;

(2) They redirect the light so that to spectators in the balcony the picture appears as good as to those on the main floor;
(3) They redirect the light in such a manner as to result in decided economies;
(4) They assist in the illusion of the third dimension;
(5) They can be satisfactorily maintained, and retain much of their original brilliancy;
(6) They reduce the glare seen from seats near the screen;
(7) Because of their apparent brightness, they add life and brilliancy to color pictures.

The disadvantages of directive screens are:

(1) They are not desirable for theaters having projection angles greater than 20 degrees because of their directive nature;
(2) They are not desirable for wide houses.

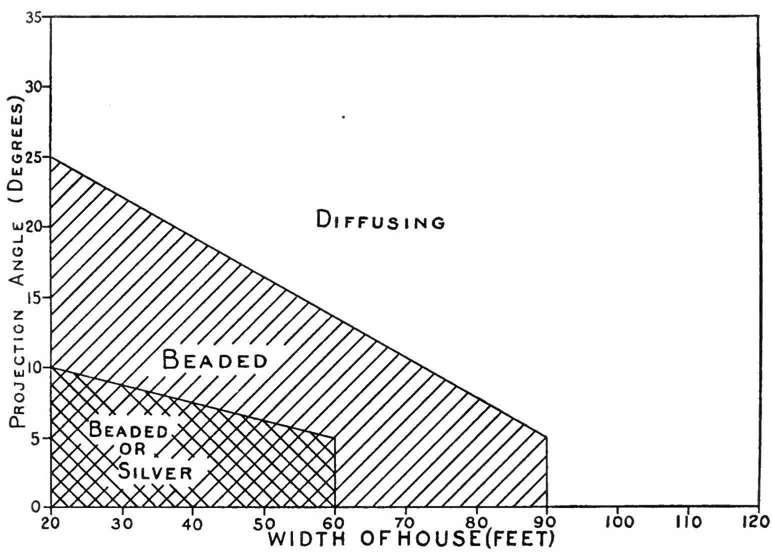


FIG. 3. Showing relation between width of house and angle of projection.

In conclusion it may be stated that beaded screens, while very efficient, redirect the light and provide a more satisfactory picture in houses of medium width having projection angles up to 20 degrees. Because of the great brilliancy and the decided contrasts, the tone qualities of the picture are enhanced, especially in the case of color pictures. Beaded screens also redirect the light so as to provide those in the balcony with as good a picture as those on the main floor.

Selection of a Screen

Invariably, it is a mistake to select a screen for one theater by viewing a screen in another theater. The many whims of projection equipment all contribute to mislead the observer, and in the final analysis, the characteristics of the houses will probably differ so much that a proper choice is impossible. Then, too, our eyes are not trained to evaluate the brightnesses in cases such as these.

Consideration of the foregoing analysis, the charts of Fig. 3 and Fig. 4, and the physical characteristics of the particular theater for

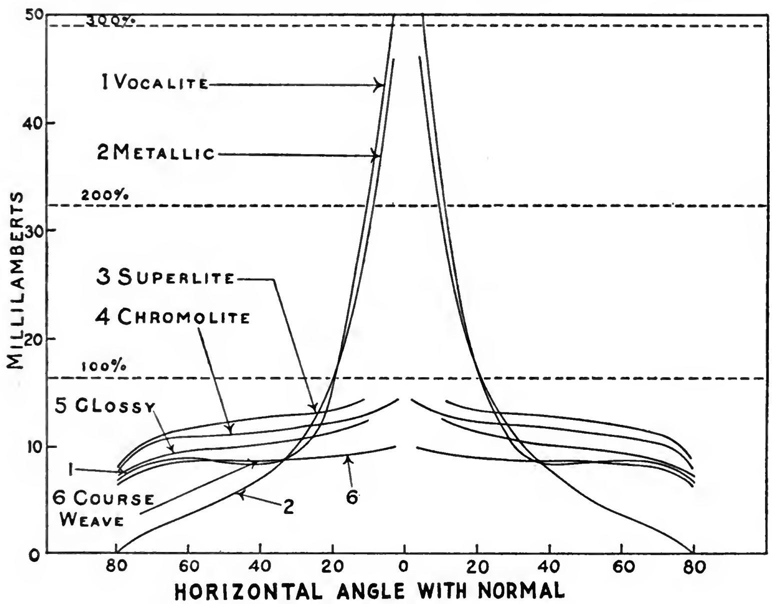


FIG. 4. Brightness characteristics of various screens.

which the screen is intended, will permit the selection of the best type. The other factors which follow will assist in making the proper selection of the best screen of that type.

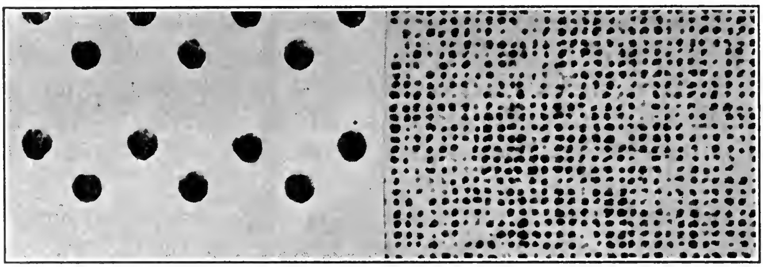
(2) REFLECTIVE EFFICIENCY

The total reflection of light from a screen, apart from measurements of its reflection characteristics in various directions, is very important, as it is on this factor that one phase of efficiency depends. Of two similar types of screen, the one with the highest over-all

efficiency is likely to prove best. This is illustrated in Fig. 1, where the largest curve indicates the most efficient screen. The reflective efficiency of the screen is closely linked with the reflective efficiency of the coating material, titanium pigment being an excellent white reflective pigment. Aluminum, on the contrary, has relatively low efficiency, and consequently metallic screens are usually of low efficiency. Light tests of screens should include measurements of reflective efficiency.

(3) SOUND CHARACTERISTICS

In practically all cases, horns are now placed behind the screen, the sound passing through the screen *via* interstices in woven cloth or perforations in opaque material. When this method was first



Perforated Porous-Beaded

FIG. 5. Screen openings for transmission of sound.

used, the matter of sound transmission was considered all-important, compared with other considerations, and the picture suffered decidedly. It was later found that a relatively small percentage of open space—as low as 4 per cent—could be used, the present compromise being about 8 per cent. An arbitrary figure of approximately 3 decibels loss was decided as allowable by Electrical Research Products, Inc. The RCA and other manufacturers have allowed somewhat greater tolerances. Considering the great losses in other parts of the system, such as in the horns, the allowable loss for screens would seem rather severe, but fortunately, a fairly good picture can be produced on a screen meeting this requirement. Also, because of varying methods of test, it does not seem possible to make two tests that check, so that, under the present system, the value of these tests is questionable.

Fig. 5 is given as a matter of interest, showing the openings in a porous and a perforated screen, magnified 100 times.

(4) DURABILITY

Under this subject the following factors must be considered:

(*a*) The ability of the screen to withstand abuse, during handling and hanging;
(*b*) Its strength at the seams;
(*c*) The effect of dirt collection;
(*d*) The effect of washing and reprocessing.

The abuse that the average sound screen receives is astonishing. When hanging the screen, often too little care is taken, and there is always the possibility of tearing or damaging the surface. Accompanying all new screens are carefully written instructions which are very valuable to the exhibitor in regard to saving time and obtaining the proper service from his screen. Ruggedness of material is a factor to consider in selecting a screen, but any screen is likely to suffer because of abuse. Furthermore, ruggedness seems to play no part in its life, as other factors, such as the collecting of dirt and method of maintaining the screen, are more important. The seams should be as strong as possible, but no seams will withstand considerable abuse.

The accumulation of dirt, the washing of the screen, and methods of reprocessing it are the factors which determine the life of a sound screen. If properly maintained, screens may have an effective life of one and one-half to two years. The average effective life of a sound screen is one year; screens kept in service longer than this handicap the exhibitor to a considerable extent unless they are properly and regularly serviced.

(5) UNIFORMITY

Two factors must be considered under this heading: (*a*) the uniformity when new, and (*b*) the uniformity after being used a while and after cleaning or reprocessing.

The slightest imperfection in weave or variations in depth of coating may result in a non-uniform surface; this may happen even when the greatest of care is taken. Panels must therefore be carefully matched and inspected to see that they are of the same color and are free from imperfections.

The processing must be so uniform and exact that surface conditions and time will not cause a lack of uniformity. All screens in use today become yellow with age to a certain extent. If the yellowing is uniform, it is not likely to be objectionable. Improper

cleaning or reprocessing may introduce streaks and imperfections, and may considerably increase the tendency to become yellow. At the time of processing, the screens may have a uniform appearance, but when dry the imperfections will gradually appear. Be sure that this is given consideration before allowing a screen to be resurfaced.

(6) FIREPROOFING

Some time ago, because screens were made of highly inflammable cellulose materials, considerable agitation was raised in certain quarters concerning fireproof screens. By adding certain ingredients and eliminating others, the various screen coatings were made fire-resistant. Fabrics are best made fireproof by impregnating them. A slow-burning material, however, when stretched vertically, does not constitute a fire hazard; but if a fire-resistant material is selected, there need be no fear of objection by local inspectors.

Successful fireproofing of a screen immediately after it is made or while in place in the theater has not yet been accomplished. Screens are such a small item of the stage equipment, and so much less inflammable, that there need be no fear of fire from them. In general, it is best for each exhibitor to choose his screen according to his local ordinances.

(7) ILLUSION OF DEPTH

The illusion of depth is a very debatable matter; it seems to be connected with the method of photography used. By obtaining the proper contrast between highlights and shadows, an illusion of depth seems to be created. Beaded screens have been selected for wide film projection in a number of instances because of this feature.

(8) ADAPTABILITY TO COLOR

Color brilliance and purity is, to a considerable extent, dependent on the light intensity. For this reason a bright screen will, in general, if of neutral character, give better results for all colors than a screen which is less bright. For colors, screens should have no tint other than that which is required to neutralize the color of the light source, assuming that it has a definite color. A metallic screen is usually quite color-selective, whereas beaded and white diffusive screens are neutral in character. Closely paralleling this problem is that of obtaining the correct tone quality of the reflected picture. Attempts to tint the screens in order to impart a certain tone quality to the picture are likely to be undesirable when colored pictures are

projected, and because of the different qualities of the various arc sources themselves.

(9) SIZE OF SCREEN REQUIRED

The problem of choosing the proper size of screen is an important one. A new installation is the simplest to plan, but when a theater needs a new screen, the problem should be carefully considered. The problem is of sufficient importance to warrant the replacing of the objective lens if a different size of screen seems desirable.

Standard Sizes.—A system of standard screen sizes is highly desirable, and will result in economies and other advantages for both the exhibitor and the manufacturer. Less wastage results, errors in ordering are made less frequently, shipping is expedited, cleaning is facilitated, and costs and prices are consequently reduced. The Projection Screens Committee of the Society of Motion Picture Engineers is now developing recommendations for standard sizes. Information based on standards adopted individually by large circuits and manufacturers gives the following list of sizes:

Description	*Picture*	*Screen*	*Inside of Frame*
Standard	9′0 by 12′	9′6 by 12′6	10′6 by 13′6
Substandard	10′6 " 14′	11′0 " 14′6	12′0 " 15′6
Standard	12′0 " 16′	12′6 " 16′6	13′6 " 17′6
Substandard	13′6 " 18′	14′0 " 18′6	15′0 " 19′6
Standard	15′0 " 20′	15′6 " 20′6	16′6 " 21′6
Substandard	16′6 " 22′	17′0 " 22′6	18′0 " 23′6
Standard	18′0 " 24′	18′6 " 24′6	19′6 " 25′6
Magnoscope	24′0 " 36′	25′0 " 37′0	26′0 " 38′0
"	26′0 " 40′	27′0 " 41′0	28′0 " 42′0
"	28′0 " 40′	29′0 " 41′0	30′0 " 42′0

Wherever possible a standard size should be substituted for a non-standard. When ordering screens, the three dimensions should be given; prices are based on picture sizes.

HOUSE CONDITIONS

Theaters are planned with definite lines of sight, and care must be taken to keep the screen in the line of vision, especially when using a screen modifier. Older theaters generally used a line of sight which provided a clear view of 16 feet from the stage floor at a point 4 feet back of the curtain line, which therefore often limited the size of the screen to 15 by 20 feet. Newer theaters often allow for a

considerably greater height. The accompanying diagram (Fig. 6) illustrates these limitations.

The distance from the front row of seats to the screen is one of the determining factors for the size of the screen. The larger the picture, the worse will the imperfections, such as graininess in the film, appear.

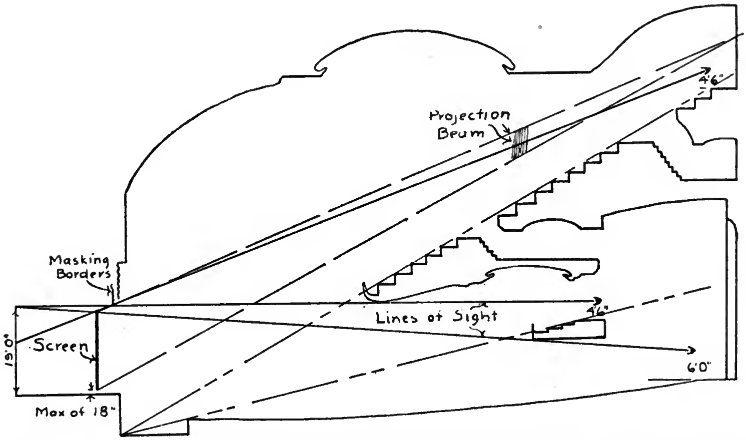


FIG. 6. Factors limiting the size of screen (typical motion picture theater).

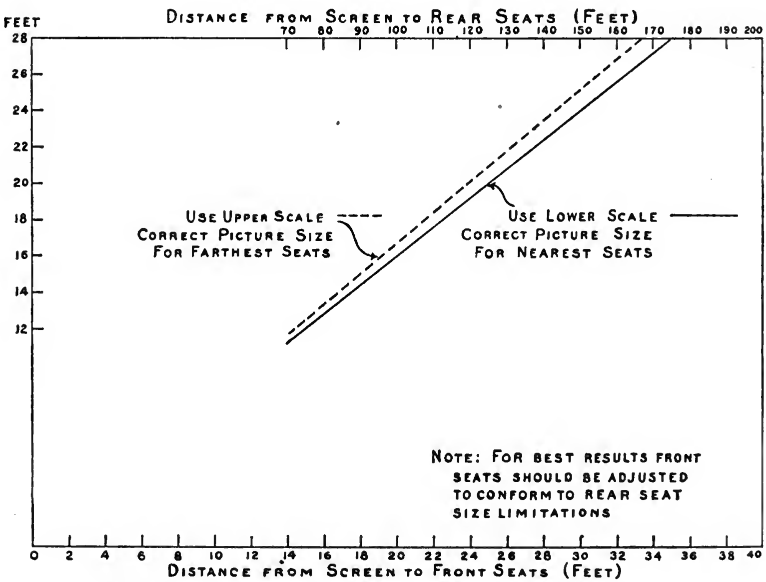


FIG. 7. Curves for determining proper size of picture.

These imperfections are very noticeable and objectionable to spectators sitting close to the screen. The eye can satisfactorily accommodate itself over an angle hardly more than 45 degrees, so that the distance of the front row from the screen should be approximately 15 inches for each foot of screen width. For a 15-foot picture, a distance of at least $18^1/_2$ feet should therefore be provided.

The size of the picture should also be determined by its distance from the rear seats. The width of the screen should be approximately $^1/_6$ the distance from the screen to the rear seats. For a distance of 120 feet, therefore, a 20-foot picture should be provided. Fig. 7 shows curves which may be used in determining the proper size of the picture.

PROJECTION EQUIPMENT

The intensity of the lamps, the perfection of the optical system, and the length of throw should also aid in determining the size of the picture. Here, however, the character of the screen must be considered. If it is of the beaded type, in a house adapted to it, a considerably larger picture can be used because of the increased brightness of the picture as seen from most seats.

It is a fact that the smaller the screen, under a given set of conditions, the brighter it appears. For this reason there is a definite maximum limit to the size of the picture when using Mazda or low-intensity arc lamps of 18 to 28 amperes. Practical tests have determined these sizes to be as follows:

Light Source	*Screen*	*Throw*	*Picture*
Mazda	Diffusive	100 ft.	12 × 16
"	Beaded	100 "	15 " 20
Low Intensity	Diffusive	125 "	15 " 20
Low Intensity	"	175 "	12 " 16
" "	Beaded	125 "	18 " 24
" "	"	175 "	18 " 24

This table is based on the best figures available at this time regarding screen illumination, which varies from 3 to 7 foot-candles with the shutter in operation, for a picture of average size. For Hi-low and high-intensity light sources, there seem to be no limitations beyond the reasonable ones already placed.

It should be remembered that when a given light source at a given distance is used to project on a larger screen, the screen brightness will be lessened, just as a 25-watt lamp in a small room will light a

theater auditorium much less brightly. A 12 by 16-foot screen having an area of 192 square feet is almost twice as bright as a 15 by 20-foot screen having an area of 300 square feet, under the same conditions. Therefore, if a screen is not already more than bright enough, a change to a larger screen should not be considered unless it is to be changed to the beaded type.

LARGE PICTURES AND COMPETITION

Practical showmanship is responsible at times for causing exhibitors to do things that may not be technically correct. The excitement about large pictures (which was accomplished practically, but not satisfactorily, by merely changing the sizes of screen and picture) caused the exhibitors to feel that it is necessary to have a larger screen than is ordinarily desirable. The maximum size of picture, except in unusual cases, should be 18 by 24 feet. If a screen modifier is to be used, there must be sufficient difference between the sizes of the small and large pictures to make the effect worth while. A change from a 20 by 26-foot picture to a 24 by 36-foot picture would not be desirable; however, a change from a 15 by 20-foot standard picture would provide the desired effect.

POSITION AND SURROUNDINGS

Local conditions determine to a great extent the location of the screen. In general, it may be said that the illusion of realism is best maintained by placing the screen either as close to the floor as possible or not more than 18 inches above it.

When possible, the floor of the stage on the house side of the screen should be covered or painted with a dark non-reflecting, non-glossy material, as the stage floor produces annoying reflections of the picture.

The screen should, of course, have a mask around it to properly frame the picture, and to reduce the "jumping" effect which occurs when poor film or poor equipment is used. This mask is usually a black cloth free from gloss, but at various times a less absorptive material has been advocated to reduce the sharp contrast between the frame and the picture. Because of jumping, it is not desirable to use a light material next to the screen; the desired effect may be accomplished by a graded surface, with the darkest material adjacent the screen.

TILTING OF SCREENS

Sometimes screens are tilted in order to correct for keystoning, or, with silver screens, to redirect the light to better advantage. This is a difficult problem, and furthermore, it might be stated that a

tilted screen collects more dirt than an upright screen. Tilting should be restricted to silver screens.

Keystoning and side-view distortion are due to large projection angles or poor perspective, and cannot be corrected by using a modified aperture plate. Side-view distortion cannot be corrected, but can be avoided to a certain extent by keeping the screen as far from the front seats as possible, and by eliminating the wide front seats.

HOUSE LIGHTING

The principles of correct lighting for theaters are so well known that only a few of them will be mentioned here:

(*a*) The intensity of illumination should gradually diminish from the street to the auditorium, so that the eyes may gradually become accommodated to the low intensities.

(*b*) Auditorium lighting should be of low intensity. The auditorium should be only sufficiently bright to permit patrons to readily locate empty seats, and not so bright that they will be distracted by movements of other people. Less light is needed in the front of the auditorium.

(*c*) All light sources should be diffused so that no points of considerable brightness are apparent, and no lights should be near the line of vision when viewing the picture.

(*d*) The light should be so deflected that as little as possible falls on the screen.

INSTALLING THE SCREEN

The manner of installing screens has an important bearing on the results obtained with them and the economies effected. A few rules for installing screens will therefore be given. However, when manufacturers' instructions are available, they should be followed to the letter.

(1) Whenever possible, and wherever a screen is smaller than 15 by 20 feet, the screen can best be installed by assembling the frame on the stage or on the seats (Fig. 8), with the top toward the place the screen is to be.

(*a*) Lace the left side, which is the top screen surface, on the roll. Follow with the top and bottom of the screen, and then the right-hand side.

(*b*) When the screen is in place, tighten the laces; in the case of a beaded screen, where there is no need for extreme tightness, do not stretch other than to remove the wrinkles.

(2) If the frame is already in an upright position, a line should be fastened to the shipping roller and the screen should be

raised into place on the left side of the frame, rested on the bottom rail, and fastened by the line to the top rail. Care should be taken not to crush the screen or allow the material to sag from the roller.

(*a*) With small pieces of line, starting at the corner grommet, tie the screen into place at the top grommet, unrolling the screen as each grommet is tied to the frame.

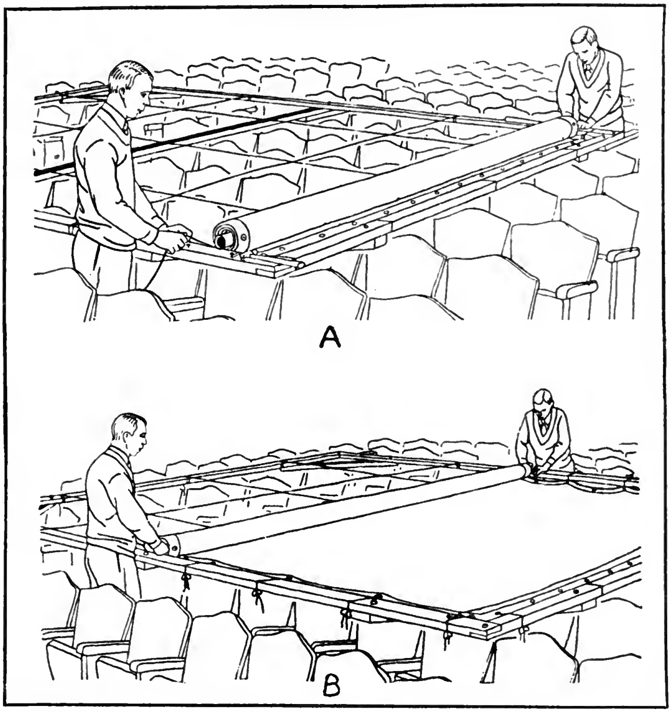


FIG. 8. (A) Unrolling the screen on the frame; (B) the screen partly unrolled.

(*b*) Lace the top of the screen after it is temporarily in position; then lace the bottom, and finally the sides.

(*c*) When the lacing is finished, tighten it gradually to free it of excess wrinkles. Do not stretch tightly.

MAINTAINING THE SCREEN SURFACE

There are four phases to the maintenance of screens; one pertains to the preventing of dirt from accumulating on the screen; another to freeing it of excess dirt; the third to a complete and thorough

cleaning of the screen; and the fourth to the renewing of the surface. The final objective is to keep the screen surface as nearly perfect as possible at all times by taking all precautions and by systematically attending to it.

SURFACES

The surfaces of sound screens have very dissimilar characteristics. Some are very rough, some smooth, some hard, and some are sticky. The perforations add much to their ability to collect dirt, and porosity of the surface adds to a somewhat lesser degree. The circulation of air through the openings also makes it easier for the screen to collect dirt. Silver screens collect dirt, just as do the beaded and white screens; furthermore, they become tarnished, resulting in a lowered reflection value. A hard white screen is better than a sticky one from the maintenance standpoint.

ACCUMULATION OF DIRT

The amount of dirt deposited on the surfaces of the screen depends on the atmosphere of the house, on the neighborhood, on the circulation of air in the theater, and on the precautions taken to protect the screen. The first step to be taken toward keeping the surface clean is to determine whence the dirt comes, and to alleviate the difficulty at its source. The following are the more obvious sources of dirt; and remedies:

(1) Dirt falling from overhead and draperies. Thoroughly clean overhead, side draperies, and masking. Prevent travelers from brushing the screen.

(2) Stirring up of dirt by cleaners. Cover the screen at night when not in use, even though with only the cheapest kind of material.

(3) Circulation of air through the screen. Close doors, *etc.*, which cause drafts, and back the screen, close to the horns, with a neutral gray material to prevent air from circulating through the openings.

BRUSHING

Even after taking all these precautions, the screen will collect dirt. Inspection will indicate whether the dirt is dry or greasy and, therefore, whether the screen can be brushed. If the dirt is dry, the screen should be brushed with a long-handled special screen brush. It is also well to vacuum-clean the back of the screen once a week. The brush should be kept clean.

CLEANING

No satisfactory method of cleaning screens has been suggested as yet. It is possible to clean small samples of screen material, but the cleaning of screens installed in the theater or when returned to the factory is not practicable. The screen sags, and water soaks in at the perforations, causing deterioration of the surface. Streaks result from unequal drying. The soap causes the screen to become yellow after a few days. If screens must be cleaned, however, there are certain instructions which, if followed, will produce better results than are usually obtained:

(1) Great care must be taken;
(2) Use two buckets, one for the cleaning solution and the other for clean water;
(3) Keep the water and solution clean at all times;
(4) Free the surroundings and screen of excess dirt before cleaning; vacuum preferably;
(5) Use soft sponges and keep them dry, so that no water will run down the screen;
(6) Work from the bottom to the top of the screen;
(7) Use plenty of light.

REPROCESSING

Replacing the surface of diffusing screens by spraying is receiving considerable attention. When carefully done, and when the proper material is used, a satisfactory job may be possible. The material should have a high reflection value, and should become yellow as little as possible. Here again, the screen and its surroundings should first be cleaned thoroughly.

In conclusion, in order to properly select, purchase, install, and maintain a screen, the following outline should be carefully followed:

(1) Decide on the proper type of screen for the house.
  (*a*) If the projection angle is less than 20 degrees and the house is not extremely wide, use a beaded screen.
  (*b*) If the projection angle is greater than 20 degrees or the house is extremely wide, use a matte screen.
(2) Choose the best screen surface of this type.
(3) Analyze the house conditions and select the proper size of screen.
(4) Install the screen properly, following the manufacturer's instructions.
(5) Permit no circulation of air through the screen.
(6) Cover the screen when not in use.
(7) Brush the screen regularly once a week, with the proper kind of brush.

DISCUSSION

PRESIDENT CRABTREE: How are the screens cleaned? If the brush method is used, how are they brushed? Is the screen taken down from its position or is it brushed in place? Also, how is the screen resurfaced? What is the cost of resurfacing in comparison with the cost of the screen? Is it worth while?

MR. FALGE: The screen is cleaned in position with a very soft, long-handled brush. Cleaning is very simple, but is often neglected. Some one in every theater should be given the responsibility of keeping the screen clean. The cost of taking down the screen, packing and shipping it to be resurfaced, and mounting again is so great that it is better to clean the screen in position. Screens may be resurfaced in a number of ways, the spray process being the most satisfactory. The cost of this treatment varies in different places, from 10 to 20 cents per foot. A new screen may cost from $2^1/_2$ to 4 times the cost of resurfacing, depending upon the amount of surface to be treated. Screens can be resurfaced satisfactorily, but in general, the process is not satisfactory, as the material used for resurfacing becomes yellow and is not always put on uniformly.

PRESIDENT CRABTREE: What is the effect of spraying a beaded screen? Is it cleaned by spraying, or were you referring to diffuse screens?

MR. FALGE: I was referring to diffuse screens. No good is accomplished by spraying a beaded screen, as the spraying causes the beads to lose their directive qualities. In general, it is extremely difficult to properly clean screens on account of the wide expanse of the flat surfaces. Beaded screens can be cleaned satisfactorily, but the process is very complicated.

PRESIDENT CRABTREE: Could some solvent be used for cleaning the beaded screen?

MR. FALGE: To a certain extent; but the solvents that have been tried have loosened the adhesion of the beads and so such methods have not been found satisfactory up to the present.

PRESIDENT CRABTREE: The matter of standardizing screen sizes is very important. Has this matter been brought to the attention of the Projection Screens Committee?

MR. FALGE: Yes, but nothing definite has been done about it as yet.

MR. SCHLANGER: The information given in this paper referring to the proper distance between the seats and the screen is very important and should be referred to the American Institute of Architects. In relation to the shape of the screen, I suggest that perhaps Mr. Dieterich might say something about the restful physiological effect of the 3 to 5 ratio on the human eye.

MR. DIETERICH: Yesterday I briefly mentioned the fact that there is a minimum distance required between the eyes and the screen for comfortably viewing the picture. To go a little deeper into the discussion we must consider the sight characteristics of the eyes, which when plotted, assume a peculiar egg-shaped form for each eye. The combination of the two characteristics produces a more or less heart-shaped curve for the combined characteristics of the two eyes—*i. e.*, for binocular vision. If we inscribe a rectangle into the combined characteristic we are led to the classical ratio of height to width of 1 to 1.6. As long as we have to change the proportions of the visible picture—which we must do sooner or later—we should consider the esthetic demands, because they control to a great extent the reaction of the public, which again influences box-office re-

turns. As long as it is necessary to change the dimensions, I am endeavoring to advocate that we should change in accordance with this ratio. There will be a number of technical difficulties, and problems to overcome, but they will have to be overcome sooner or later, in any event. The Standards Committee has suggested a 50-mm. width for production reasons, but we can just as well use the proper proportions for this width as for any other. Mr. Schlanger suggested that when one sits in front of a screen that is 40 feet wide, he may come closer than 40 feet. However, this would not place the screen within the "easy" range of the eye. The eye must exert an effort to encompass an angle greater than 60 degrees and although our total vision is limited only by about 180 degrees, it becomes a painful effort to use it to its full extent. Along the horizontal axis of vision, the "easy" range is normally 30 degrees on each side, and along the vertical axis about 10 degrees above and 20 degrees below the horizontal. If the scheme of Mr. Schlanger is in accordance with these physiological facts, he will find that the spectator will enjoy the picture more than in the past. As to the question of depth perception, the recognition of depth in the wide picture is due to the fact that when one looks at a wide screen, the distances to the edges of the picture are perceptibly greater than the distance to the center, and the eye has to accommodate itself to such different focal values. Therefore, the only means of perception, which is by the final nerve center, would cause a reaction, resulting in a muscular effort to accommodate the eye. Therefore, the wide picture has certain disagreeable effects for the present front seats, but which lessen as the distance from the screen increases. The minimum distance between the screen and the front seats, should not be less than the width of the picture.

MR. FALGE: The ratio you suggested is close to the 3 to 5 ratio which I mentioned previously.

MR. JONES: There was one statement in Mr. Falge's paper I should like to question. In discussing the diffusing type of screen he stated that the brilliance of the screen depends upon the viewing distance. I cannot see why the argument applies to the diffuse type of screen and not to the beaded type. It is quite possible that the brilliance of the screen—that is, the apparent brightness—is to a certain extent influenced by the angle of the screen and by the surroundings. I think it is quite possible—and I know it is true—that whether the screen appears to be more brilliant at one distance than at another will depend upon the surroundings of the screen. I think we should recognize that that characteristic, which may be a true phenomenon, is a characteristic of all types of screens, and I cannot see that it is a characteristic of a diffuse type of screen any more than of any other.

MR. FALGE: What I meant to convey was that this effect is more pronounced in the case of the beaded screen. I referred to it briefly in connection with the beaded screen. As far as the surroundings are concerned, if too much light is present, the pupils of the eyes become smaller and the screen does not appear as brilliant as one would like it to be.

MR. OTIS: Have any measurements been made on the diffusiveness of the screens to color?

MR. FALGE: Do you refer to a particular one of the three types, or to all screens? I do not believe that such measurements have been made.

MR. SCHLANGER: Referring to the shape of the picture and the desirability of retaining the 3 to 5 ratio, it is possible to change the shape of the screen throughout a picture so as to present different geometrical forms—triangular, rectangular, circular, *etc.* I understand that some work has already been done along that line.

MR. DIETERICH: Madame Ducat, the only female member of the Legion of Honor, has invented a new "panel" aperture. Her idea is that everyone who has a sense of the artistic frames a picture or composition according to the composition, and does not take the frame and fill it with the composition. The frame should be under the control of the cameraman so that he may instantaneously alter the picture frame as desired. This does not depart from the 1 to 1.6 ratio for the shape because this ratio is an esthetically fundamental one from which any number of frame sizes can be developed. Her idea of changing the frame size according to the action has been successfully used because she understands the correct use of the panel frame.

SYMPOSIUM OF NEW MOTION PICTURE APPARATUS

Summary.—*An innovation at the Spring, 1931, Meeting of the Society at Hollywood, Calif., was an exhibition of new apparatus held in the annex of the American Legion Auditorium. The exhibit aroused such great interest that it is hoped to hold similar exhibits at future conventions.*

Exhibitors were required to conform to the following regulations: (a) It was necessary that the apparatus be new or have been developed or improved within the previous twelve months; (b) No pamphlets or advertising literature were permitted; (c) Each exhibitor was permitted to display a small card giving the name of the manufacturing concern and each piece of equipment was labeled with a plain label free of the name of the manufacturer; (d) A technical expert capable of describing the features of the apparatus exhibited was required to be present during the period of the exhibition.

PORTABLE RECORDING SYSTEM FOR STANDARD CAMERAS*

This recording system was primarily designed for industrial, news, and travel work. It employs two direct current motors operating in synchronism, and enables the cameraman to use any motion picture camera in synchronism with the recorder and produce a separate sound track on positive film. The camera motor hangs under the camera by two straps which are snapped on and off quickly, and operates the camera through a flexible shaft which can be plugged into the regular Bell & Howell or Mitchell cameras. The motors operate on 10 volt d-c. and are electrically interlocked for synchronism (Fig. 2).

Fig. 3. shows the recording head. A tachometer, footage counter and a 1,000 ft. Mitchell magazine are included. The motor mounted on the base is one of the d-c. interlocking motors. One switch controls the recorder, another switch the camera motor, and a third is the interlocking switch which throws the camera and motor into synchronism. The recording lamp holder is removable for cleaning and threading. When replaced it slips on a pilot pin with a stop screw so that it will always be in proper register. A mechanical filter is included between the motor and the recording head.

The amplifier consists of 4 resistance-coupled stages, provision being made for accomodating two microphones. A lamp voltage regulator, plate current meter, and volume indicator are also included

* Audio-Camex System of the Hollywood Camera Exchange, Hollywood, Calif.

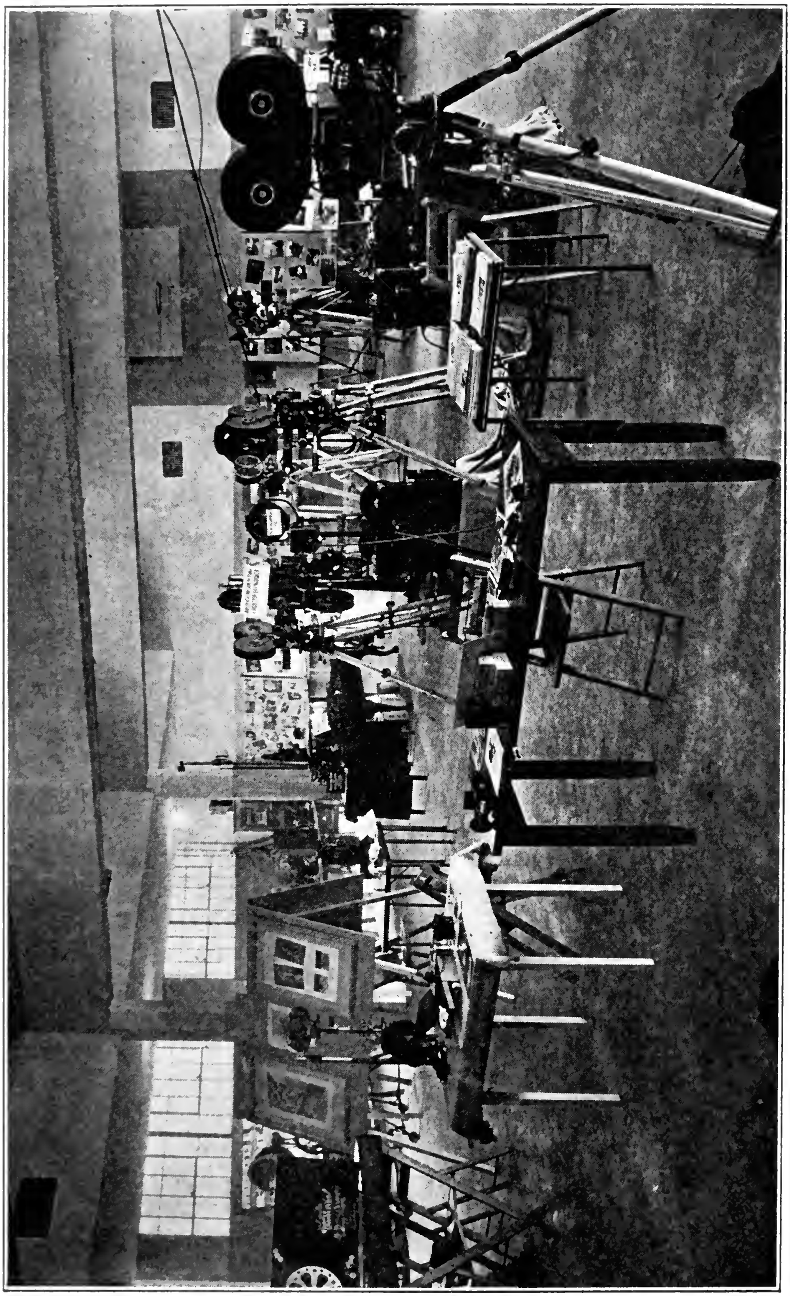


FIG. 1. Apparatus exhibit, Hollywood Convention, May, 1931.

with the amplifier. The recording glow lamp used is known as the Audio-Lite and is said to have a life equivalent to the recording time of 30,000 to 100,000 feet. of film. Its impedance is about 7,000 ohms, and it is constructed of non-volatile electrodes.

The amplifiers, motors, recording head accessories, *etc.*, are all contained in seven metal cases.

All the connectors are arranged differently; the microphone connectors are 5 point connectors, the battery cable connectors 6 point, and the Audio-Lite connectors 4 point, *etc.*, thus making it impossible to connect the apparatus incorrectly. The bullet type microphone is a two stage microphone and is used as a condenser transmitter. It is mounted on the swivel head and has a cannon connector. The microphone stand is collapsible.

FIG. 2. Audio-Camex portable recording system attached to a camera.

A CAMERA WITH OPTICAL INTERMITTENT*

The Moreno-Snyder continuous camera employs an optical system in which the image is moved in synchronism with the film by means of a single moving part which intercepts the light. The light passes directly from the objective to the film through the optical system without being handled by reflectors or similar elements. A means is provided for controlling the framing of the picture on the film in addition to a light control for governing the exposure. The film moves continuously, and the film feeding mechanism is synchronized with the moving element of the optical system. Included with the camera is an exposure meter employing a photoelectric cell which permits matching of the exposure for a given scene with that of any scene photographed previously. For the standard film speed of 90 feet per minute, the exposure time per picture frame is $^1/_{24}$ of a second. The lens turret provides for three lenses (Fig. 4) and the focusing position and the exposure position of either lens or camera are the same.

* Moreno-Snyder Camera Corp., Hollywood, Calif.

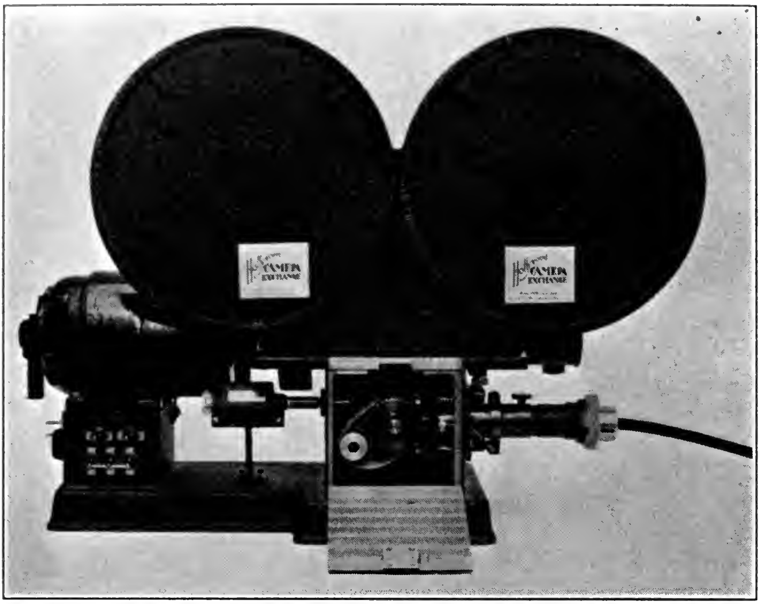


FIG. 3. Recording head of Audio-Camex portable recording system.

FIG. 4. Moreno-Snyder non-intermittent camera—front view.

By exerting a slight pressure on a small piston a prism is made to intercept the rays of light and direct them to the eye through a focusing finder (Fig. 5). This prism withdraws automatically after the third frame of film is past the aperture. The camera is silent and requires no blimp or muffler. Due to the continuous motion of the film, buckling is eliminated. Delivery and wind-up film magazines are detachable and interchangeable, while the camera can be operated as a

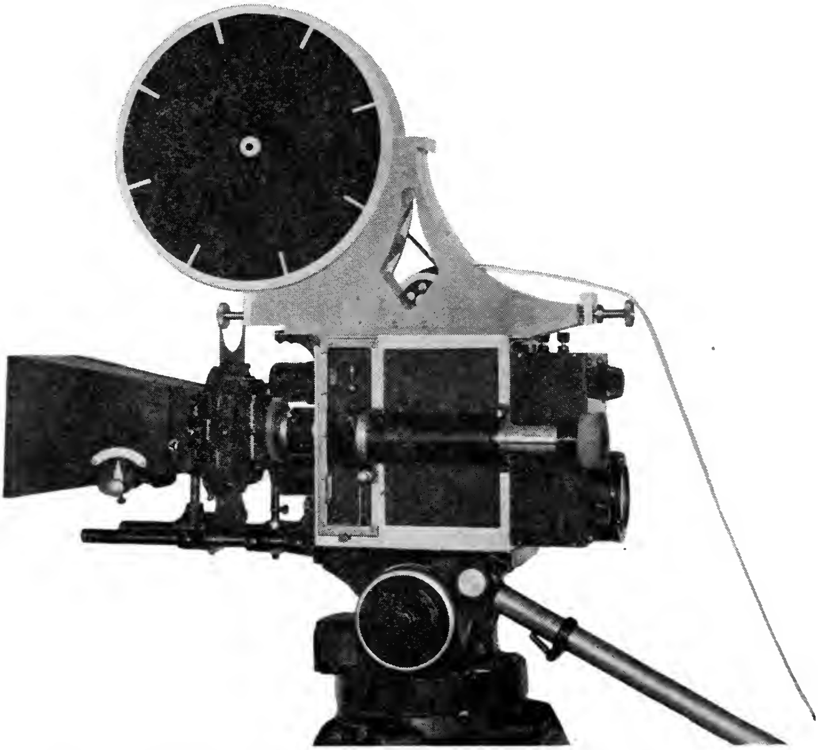


FIG. 5. Left side view, Moreno-Snyder camera showing focusing device.

speed camera for slow motion photography, and will run at 300 frames per second, or 125 ft. of film per minute, without change or adjustment.

The optical system includes a matte or exposure aperture, an objective lens, a moving lens unit, a corrective lens, and an exposure control, arranged on the camera in the order named. The moving lens unit moves the image-bearing shafts of light in synchronism with the film. It intercepts the light beam passing from the objective to

the film at one point only in the optical system, and moves it across the axis of the optical system constantly, and in a direction opposite to that in which the film is moved. The moving lens unit moves across the axis of the optical system at a point behind the objective lens, *i. e.*, at a point located between the objective lens and the film. The moving lens element is annular in general configuration and is rotatively mounted, so that it intercepts the axis of the optical system at the desired point, while the portion of the film that is exposed is

FIG. 6. Interior of Moreno-Snyder non-intermittent camera.

within the moving lens unit. In general the inner face of the moving lens unit is curved concentric with the axis of rotation of the unit, while its outer face is polygonal (Fig. 6).

A corrective lens is located immediately behind the moving lens unit between the latter and the film. The exposure control is located immediately in front of the film and includes a pair of shutter plates normally spaced apart to admit light to the film and adjustable in opposite directions parallel with the axis of movement of the film to

widen or narrow the opening through which light is admitted. Fig. 7 shows various details on the rear of the Moreno-Snyder continuous camera.

NEW SILENT MOTION PICTURE CAMERA*

This camera was designed particularly for quiet operation. The movement is entirely new, and no cams are used. The motion of the film is accomplished by eccentrics pivoted with levers, and the

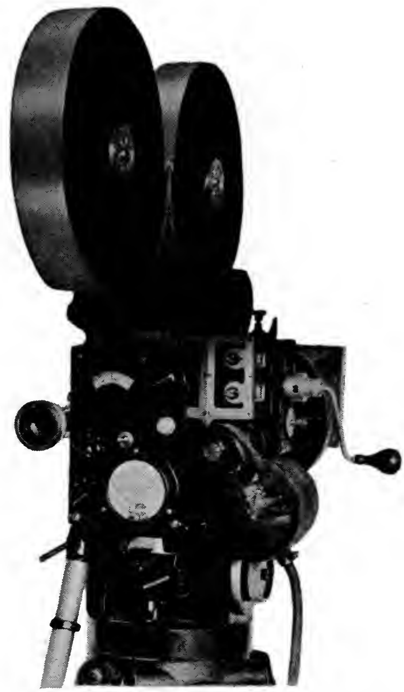


FIG. 7. Moreno-Snyder non-intermittent camera—rear view showing exposure meter and "Thermo-Head."

film travel is approximately the same as in the standard Mitchell camera. The pilot pins have a longer "dwell" or stationary period during exposure. Sawing of the film head is present but has been considerably reduced. A pair of gears from shutter shaft to movement and the worm of the shutter shaft drive the sprocket through a worm wheel. Another pair of gears is necessary in the motor mounting to change the speed to 1,440 rpm. By this means the number of

* Mitchell Camera Corp., Hollywood, Calif.

gears required is made as small as possible. The gears and worm wheel are enclosed in an oil-proof housing, while the magazine is made slightly larger to allow room for sound proofing material and more silent bearings. An adjustor plate is provided between the camera and the magazine which insulates the magazine from the camera with sound-absorbing material. An adjustor shutter is incorporated but the dissolve mechanism has been eliminated. The face of the camera is of new design, having one lens mount focused from the rear of the

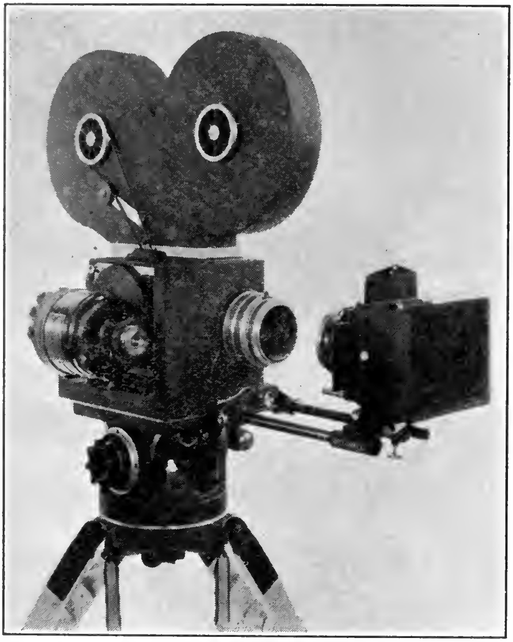


FIG. 8. Silent Mitchell camera for studio work.

camera and a scale plate in the face indicates the setting of the lens. The motor is integral with the camera door. The one shown in Fig. 8 is to be changed, and will be enclosed in a case containing sound-absorbing material.

AUTOMATIC SOUND AND PICTURE PRINTER*

This 35-mm. fully automatic sound and picture printer prints both sound and picture at a single operation (Fig. 9). Notches on the edge

* Bell & Howell Co., Chicago, Ill.

of the film and similar devices generally likely to get out of order are eliminated. Interlocking of operating levers makes it impossible to operate the machine incorrectly and means for stopping the machine automatically have been provided in case the film breaks, a lamp burns out, *etc.* After being set up, the machine only needs to be

FIG. 9. Bell & Howell 35-mm. automatic sound and picture production printer.

threaded with fresh positive stock at the completion of the printing of each reel. It runs equally well in either direction. One handle starts the machine either forward or backward, and controls the motor, brake, lights, air, vacuum tension, weights, trip locks between gates, *etc.* It is impossible to start the machine if any gate is open or if

any lamp is burned out. A traveling matte is used between the printing light and the negative film to control the printing value of the light without using notches on the film or similar devices. The traveling matte runs at one-fourth the speed of the negative, the purpose of the matte film being to secure control of the densitometric value of the final print. Densitometric control of printing light values is sufficiently exact to permit the same negative and traveling matte to be used in any printer, irrespective of location, with assurance of exact

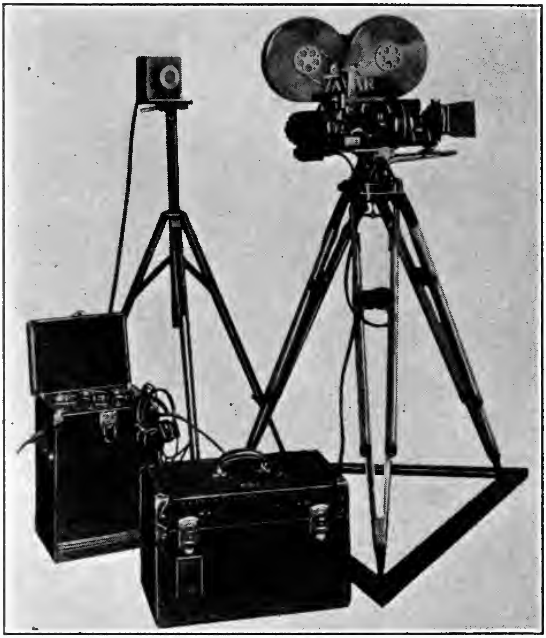


FIG. 10. Tanar portable sound recording equipment.

duplication of print densities. One operator can take care of several printers and each man should be able to handle six to twenty-five printers, depending on the nature of the work and the number of set-ups required.

RECORDING SYSTEM FOR STANDARD CAMERAS*

The complete Tanar portable sound equipment used in the single system is shown in Fig. 10. It is carried in two moisture-proof cases weighing 60 pounds each. The upright case contains the amplifier

* Tanar Corp., Ltd., Hollywood, Calif.

tube batteries for the amplifier and three batteries for supplying current to drive the camera motor. The flat case contains the "B" and "Tanar-Light" batteries, head phones, camera motor, two Tanar-Lights, and a microphone. A compartment in the lid of this case carries three cables for batteries, microphones, and camera connections. In the complete equipment a case is supplied for housing the camera. On the amplifier panel is included a volume indicator meter. The motor drive is very compact, light in weight, and is shown attached to the camera in Fig. 10. The drive operates on three "B" batteries.

FIG. 11. Photoelectric cell monitoring device.

The tachometer is carried directly to the main shaft, and the drive to the camera is completed through Celeron silent gears. A switch to start and stop the motor independent of the control panel and the variable speed knob are mounted on the motor assembly. The motor plugs directly into a Bell & Howell camera or a Mitchell camera with a suitable adaptor. A short length of cable with a Tanar socket on the end completes the connection to the Tanar-Light. The Tanar-Light is a glow tube with electrodes of tantalum. The variable density system of recording is used.

PHOTOELECTRIC CELL MONITORING*

Metro-Goldwyn-Mayer Studios of Culver City, Calif., exhibited several light valves, a photoelectric cell monitoring device, and a photograph of a new valve stroboscope. The last-named device was in use at the studio at the time and could not be exhibited. The light valves are described in Mr. O. O. Ceccarini's paper entitled "Recent Contributions to Light-Valve Technic," published in this issue of the JOURNAL. They have a single grease-damped ribbon as compared with the standard valve, which has double ribbons with no dampling.

The photoelectric cell monitoring device was designed to divert

FIG. 12. Stroboscope for viewing light valves in operation.

part of the light between the light valve and the recording objective into an efficient photoelectric cell, thereby eliminating part of the photoelectric cell amplifier and assuring quiet uniform PEC monitoring (Fig. 11).

The light-valve stroboscope is a projection microscope with a stroboscope wheel in the beam of light, which permits examination of the light valve in operation. This machine is used in the routine adjustment and maintenance of light valves (Fig. 12).

* Metro-Goldwyn-Mayer Studios, Culver City, Calif.

PROJECTION LENS TURRET*

This lens turret is adapted for use on either the standard Simplex or the Super-Simplex projection mechanism. The use of this turret makes it possible to change to any one of three lenses without having to remove them from the projector. This makes it particularly adaptable where different lenses are used on sound-on-film, silent, or sound-on-disk prints, magnascope, or other special lens effects (Fig. 13).

The turret carries three lenses in individual lens mounts, and has both tilt and pan, as well as straight, vertical, and lateral adjustment.

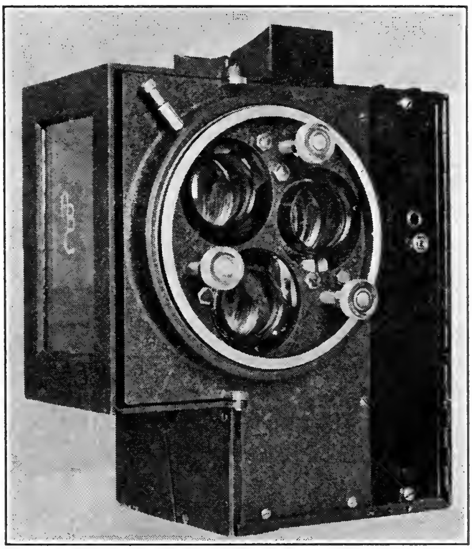


FIG. 13. A. B. C. projection lens turret—front view.

Each lens may be independently focused by a micrometer focusing screw. By means of adapters, the lens mounts accommodate all makes and focal lengths of lenses.

Any one of the three lenses may be swung instantly into position and rigidly locked by means of a hardened steel taper locking pin. The turret proper is mounted in a double race ball-bearing mount, and provision is made for adjustment to compensate for wear. The turret can be easily attached to the projector without changing the

* A. B. C. Products, Culver City, Calif.

original mechanism in any way. It is merely necessary to remove the front plate from the projector mechanism, and remove the old lens mount. Since the turret mechanism is self-contained and mounted on a new front plate it fits easily into place. The new door is so

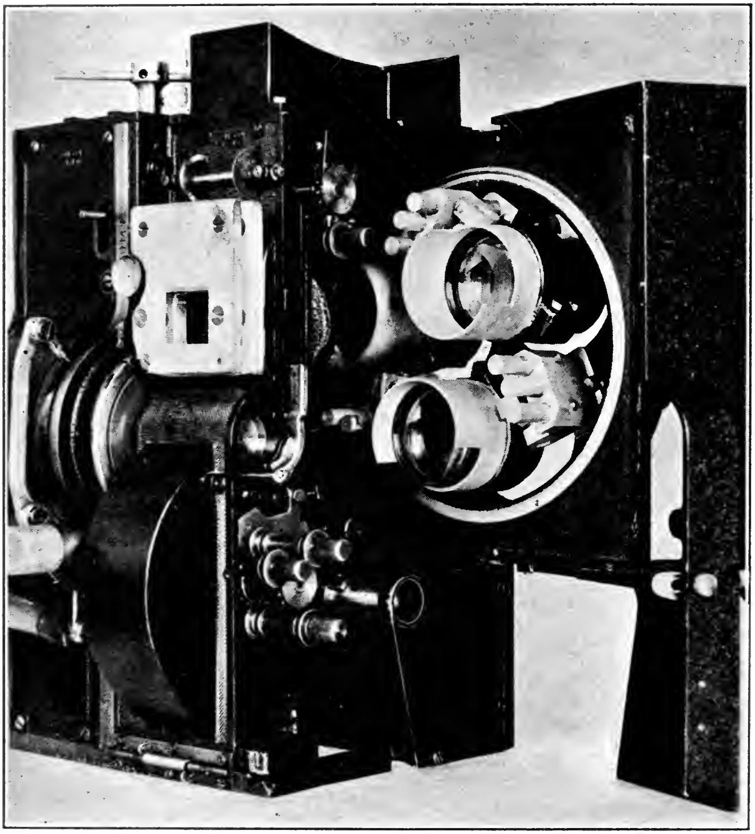


FIG. 14. A. B. C. projection lens turret—rear view.

designed and hinged that it will clear any light shield douser or other mechanism which the original Simplex door will clear (Fig. 14).

REAR SHUTTER ATTACHMENT*

Of late there has been a trend toward the larger picture in the theater. This has made it necessary to increase the light intensity in

* Fox West Coast Service Corp., Los Angeles, Calif.

order to illuminate the larger screen area properly. The resultant increase in light intensity at the source and at its concentration at the film aperture often causes sufficient heating of the film to make it warp and buckle, and get out of focus.

A device for relieving this situation, which readily lends itself to attachment to the Powers mechanism, is fastened to the head mechanism at three triangular points, making a rigid assembly which can readily be installed by any competent projectionist without extensive

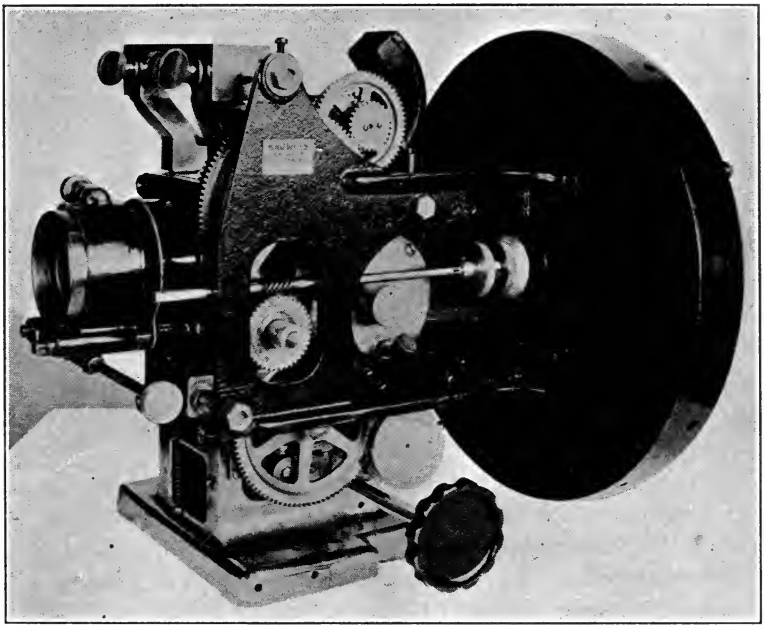


FIG. 15. Rear shutter attachment for a projector.

alterations to the mechanism (Fig. 15). The shutter adjusting device has two parts—a screw bearing and a locking nut. When the adjustment is made, this nut locks the assembly in position. The old Powers shutter assembly is discarded. The shutter housing is of cast aluminum alloy and the shutter blades are equipped with vanes which create a rapid circulation of air. The shutter shaft bearings are phosphor bronze bushings which are easily replaceable.

The standard set by other manufacturers in regard to the distance between the shutter plane and the film plane has been followed, per-

mitting any of the modern types of light sources to be used. The shutter diameter has been increased to take care of any wide angle light beam.

With this type of shutter it has been found necessary to discard the old style framing lever. In its place has been substituted a rack and pinion method of changing the position of the framing carriage, the latter being operated by a shaft which extends through the head mechanism, with a suitable knob conveniently located on each side of the projector head. The shutter shaft has been extended beyond the frame in front to allow for the use of cue-meters, speed indicators, *etc.*

A collapsible light shield has been developed, which effectively blocks out any objectionable light reflection. This is mounted on the film-gate, but in no way hampers the threading of film into the projector.

SILENT SUPER-FILM RECORDING CAMERA*

This camera is designed to be used in the open without sound-proof covering for ordinary shots; to be adaptable for use with 65 mm. film; to be readily convertible to accommodate the special 62 and 70 mm. films with which some producers are experimenting; to be used for taking colored pictures in the camera without any alteration; to be suitable for recording sound directly in the camera if so desired; and for using 35 mm. film (Fig. 16).

The camera is normally built for the standard 65 mm. film. A special movement for 35 mm. film has been developed, and this movement is interchangeable with the 65 mm. movement. Two interchangeable sprocket and roller assemblies have been developed. One is for 65 mm. super-film and the other for 35 mm. film, which are interchangeable.

By removing one movement and sprocket assembly and substituting the other, the camera can be used for either size film. This feature applies to any other size film as special movements and sprocket assemblies can be furnished for any size film up to 70 mm.

In regard to the magazines, relative to this change in film size, when the camera is purchased for 65 mm. standard film or for special size wide film, the accompanying magazines are designed so that 35 mm. film can also be used in them. This is accomplished by providing the film rollers with a relief so that the 35 mm. film is properly guided into

* Fearless Camera Corp., Hollywood, Calif.

the magazine, and by furnishing special take-up spools for the narrow film. These spools hold the film centrally in the magazine and prevent it from creeping to one side or the other.

Standard 35 mm. magazines can also be used on the camera when using 35 mm. film, making it possible to use some of the existing equipment of the producer. This is accomplished by a special adapter which fastens on top of the camera. This adapter partially covers the hole for the large size film and excludes all light from the inside of

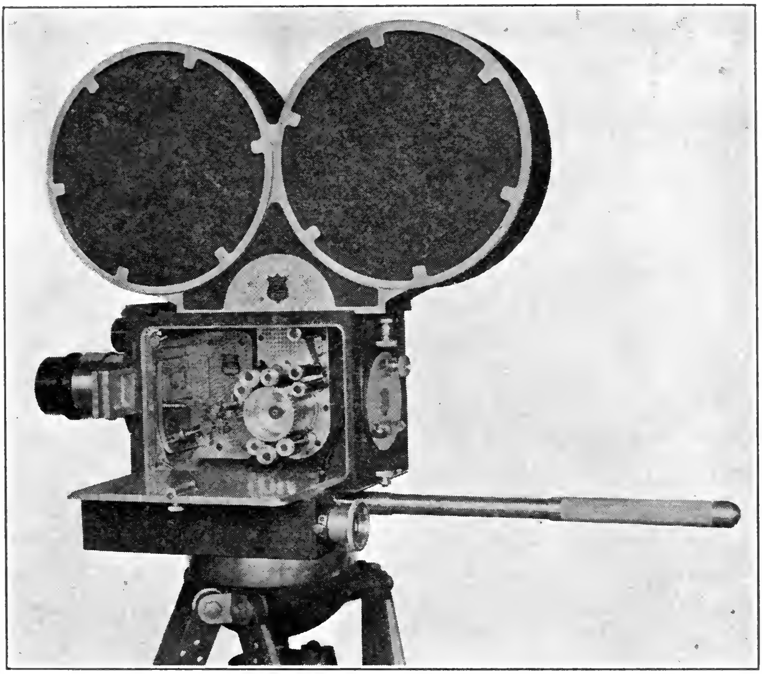


FIG. 16. Fearless silent film recording camera showing interior design.

the camera when using the 35 mm. magazines. With the adapter in place, standard 35 mm. magazines can be used.

Other features furnished as standard equipment with this camera include a quick focusing device; full force feed lubrication to all major driven parts; and two built-in footage counters. As special equipment, the camera can be furnished with a built-in speedometer, a built-in, three-speed, high-speed gear box, and a built-in sound recording mechanism.

A standard silent movement of enlarged size is used to feed the film intermittently past the aperture. Two claw pins are used on each side of the film to pull it down and pilot pins are used to lock the film during the exposure. This movement is easy to thread and, due to the simplicity of design and accuracy of workmanship, is so silent that only by placing the ear against the frame of the movement can any sound be heard while in operation.

AIR-BLAST PROJECTION LAMP*

This new lamp is composed of four units: the enclosing housing, the burner assembly, the combination arc controller and blower unit, and the heat-resisting elliptical reflector.

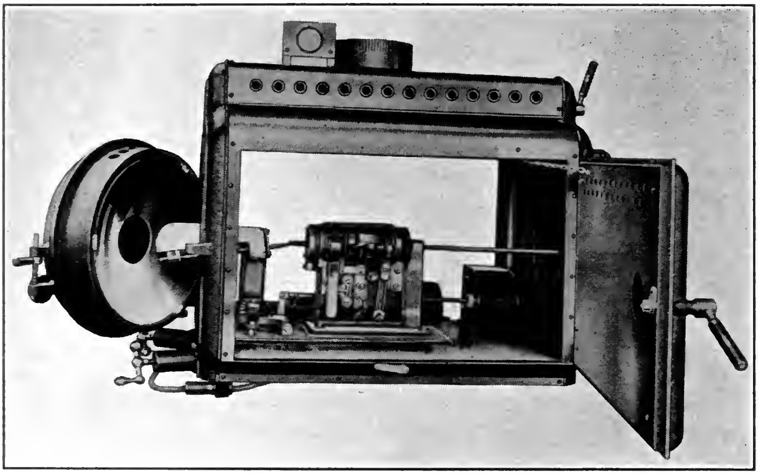


FIG. 17. Ashcraft projection lamp showing interior construction (burner assembly in center is normally covered by a plate).

A comparatively large motor is used for driving the arc control and the carbon feeding mechanism, as well as a drum-type blower rotor mounted on the opposite end of the arc control driving the motor armature shaft. The action of this rotor, which is almost silent, is to drive a strong blast of air through the working parts of the main burner or element. This blast of air, after passing over all parts subject to the effects of the radiated heat of the arc, passes out of the mechanism at an opening at the top of the enclosed burner housing, and is driven through the lamp house stack directly above the air

* Ashcraft Automatic Arc Company, Hollywood, Calif.

exit opening in the burner, carrying with it heat and gases generated within the lamp house by the arc.

The benefits of this air cooling system are: protection from oxidation of the working parts, protection of springs and heat-treated parts from over-heating, and maintenance of a temperature below the deterioration point of the lubricant. The air cooling is also applied to the contact shoes which conduct the current from the mains to the rotating positive electrode.

The working parts, such as gearing, feeding mechanism, ball bearings, contacts, *etc.*, are entirely enclosed. A plate normally covers those parts exposed in the burner assembly shown in the cut (Fig. 17). The

FIG. 18. Brenkert high intensity projection lamp.

air cooling arrangement, new contact assembly, and other features are in reality provided for the sole purpose of improving the mechanism to such an extent that it will withstand a much higher current density in the positive electrode than was formerly possible.

HIGH INTENSITY PROJECTION LAMP*

This high intensity projection lamp has all its moving parts enclosed

* Brenkert Light Projection Co., Detroit, Mich.

and protected from dirt and dust (Fig. 18). All moving parts are lubricated and are quickly accessible for removal and replacement. Means are provided for continuously feeding and rotating the positive carbon, and for intermittently feeding the negative carbon. Care has been taken to make the entire feeding mechanism extremely accurate and the feed of the negative carbon is adjusted with an accuracy generally greater than needed. Accurate and convenient means are provided for adjusting the condensing lens for focusing and the condensing lens can be separately removed from the lamp house. The lamp accommodates a 20-inch positive carbon with continuous feed throughout its entire length, and a 9-inch negative carbon. The positive carbon is released through the outside of the lamp house at the rear. The positive head unit, negative unit, control unit, condenser unit, and the entire lamp house can be taken out and put back in a few minutes, without having to make any adjustments.

Separate manually controlled handles for positive and negative carbons are provided and may be operated whether the lamp is hot or cold. A new type of arc striker is included which automatically establishes the arc and is operated at full current load without causing injury to the positive carbon. The arc striker permits trimming of the carbons in the separated position. Removal and replacement of 4 small parts permits using the 16-mm. carbon compound for those who desire to use this size carbon when projecting wide film.

FIREPROOF FILM CABINET*

This film cabinet accommodates eight 2,000-foot reels of film enclosed in double walls of 18 gauge steel plate. The walls are $1^1/_2$ inches in thickness, and are tightly filled with approved plastic fireproofing compound (Fig. 19).

The fume-tight door is fitted with an automatic self-locking device and an adjustable plunger type self-closing door pull. Adequate venting area is provided directly from the cabinet through a double walled steel vent pipe packed with fireproofing compound A humidifier provides moisture for stored film. The top of the cabinet is made at an angle to discourage the tendency to use any flat surface in a booth or storage room for miscellaneous storage. The cabinet is constructed as a unit to permit using them in pairs where fire and insurance regulations permit.

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* Neumade Products, Inc., New York, N. Y.

FILM VIEWING AND SOUND REPRODUCING MACHINES*

In editing sound motion pictures it is important that the cutter be able to see and hear the action and sound of each of the scenes to be assembled. Where the sound and picture are on separate films, this is done by adding a separate sound-head to the desired model of picture-viewer used in the past. A photoelectric cell takes the place of the light source within the machine, and a specially designed exciter-lamp unit replaces the viewing-lens, while the film is moved between the two much as in the picture-viewer, but continuously.

FIG. 19. Neumade fireproof film cabinet.

Synchronism is maintained by connecting the two units with a flexible shaft coupling, fitted with a slip-clutch, so that either unit may be operated independently. Power is supplied by two motors: the accustomed variable-speed motor on the viewer, and a constant-speed induction motor for the sound-reproducer. The two machines may be operated by either motor, or both, and both motors are reversible. Since it is desirable that both machines be kept in perfect alignment with each other, they are mounted on a sturdy hardwood stand equip-

* Moviola Company, Hollywood, Calif.

ped with casters, so that the machine may be readily moved about. In addition, this stand houses the a-c. operated amplifier for the sound reproducer, while the loud speaker is mounted above and behind the sound and picture movements. This machine is known as model UD.

For use with single-system sound and picture recordings, where the sound and picture are on the same film, and for final prints of the double-system recordings, where the sound and picture have been

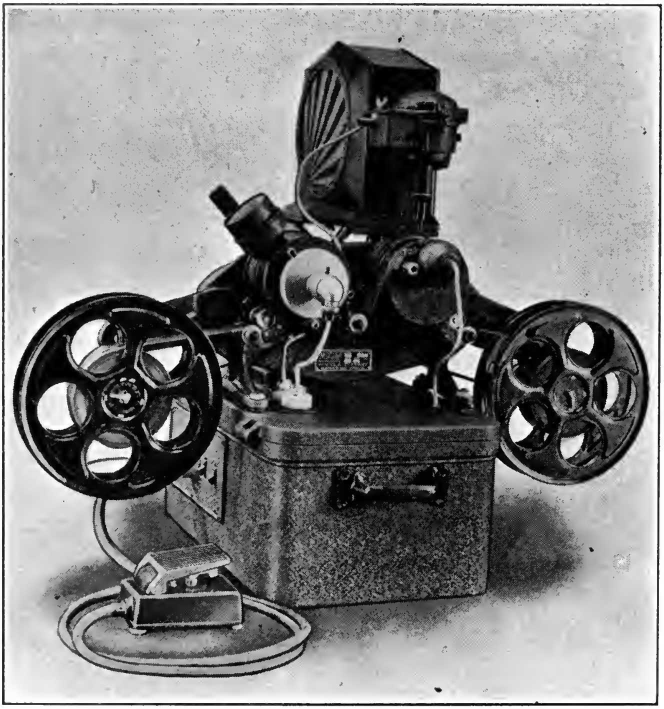

FIG. 20. Moviola sound picture inspection device for use with picture films which have the sound record on the same film.

combined on a single film, it was necessary to place a sound-head behind the picture-viewer.

In model MT (Fig. 20) the film moves continuously past both the picture aperture and the sound pick-up. The motion picture effect is obtained by means of a double walled cylindrical, rotary shutter with a slot, which revolves around the small lamp which furnishes the illumination. This shutter is geared to the film motivating sprockets so as to make one revolution per frame on the film. The double walls of

the shutter serve to concentrate the light on the film and improve the definition of the picture. The part of the film that is viewed, as well as the part that is scanned by the light line, is stretched over curved tracks. This eliminates the difficulty of keeping the film from buckling, which is encountered on flat tracks. The film is held and motivated by two sprockets, one at each end of the machine, and the tension of the film is assured by a tension roller placed in the center, between the two tracks.

The aperture over which the film passes under the viewing lens is the size of a "frame," and "framing" is effected by rotating the entire viewing system—lamp, diffuser, and viewing lens by means of a conveniently placed lever. The device is regularly operated by a constant-speed, reversible induction motor which drives it at a film-speed of 100 feet per minute. A variable speed motor may be used and this machine may be run at very high speed, if desired, without danger of damage to the film or to the machine, but running at low speed is not desirable with this machine, as the principle of its design allows only one short flash of light per frame to reach the observer's eye, resulting in flicker when the speed drops below a certain value. The entire assembly is mounted upon a metal case, which contains the amplifier, the transformer for the 6-volt lamps, and the connecting and switching devices.

A standard 50-cp. automobile headlight bulb, which is used in all the sound heads of the "Moviolas" as an exciter lamp, is used in this Model MT also as the viewing lamp, and operates from the same transformer as the exciter lamp. The latest development is a "Moviola" projector specially adapted for editorial work with sound equipment for sound on separate films as well as on composite film (Fig. 21).

There are two separate sound pick-ups, operating through a common amplifier. Either of these pick-ups may be used, and reproduction may be switched from one to the other by throwing a switch. The two units are each operated by a separate motor, a constant-speed motor for the sount unit, and a variable-speed motor for the sound-and-picture unit. Both motors are reversible, and the units may be run independently or synchronously, by means of a flexible-shaft coupling with a slip-clutch connection. The motors are controlled by either hand or foot controllers.

The lamp house of the projector is of the same design as that used for the exciter lamps of the sound pick-ups and the lamp used is the same, a standard 50-cp. automobile lamp. The illumination is

sufficient for a picture three or four feet wide at a distance of 4 to 30 feet, according to the focal length of the objective lens used. The

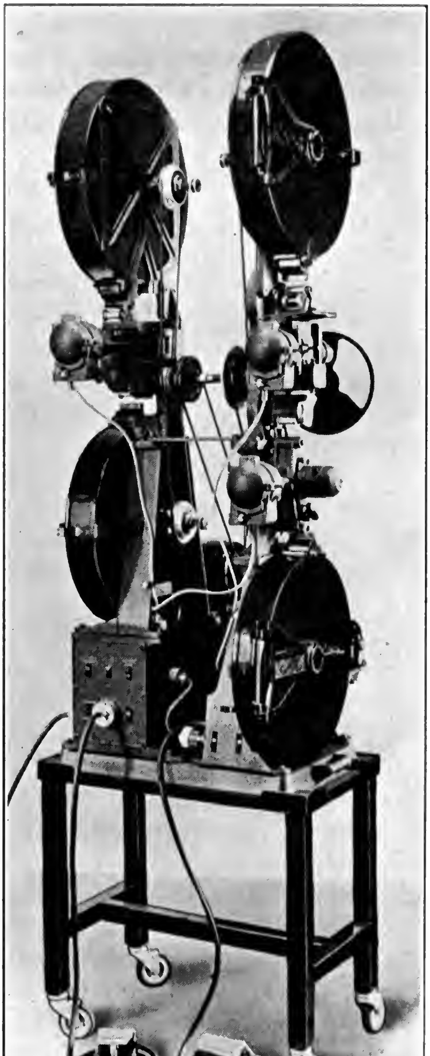

FIG. 21. Sound picture inspection projector for examining picture films which have their sound record on another film.

take-up devices are equipped with ratchets and automatically take care of the film when the direction of operation of the projector is reversed.

CAMERA AND PROJECTION LENSES*

Raytar Lenses.—A new series of photographic lenses has been developed especially to meet the ideas of the cinematographer working at a speed of $f/2.3$ and a range of focal lengths from 35 mm. to 152 mm. Tests have shown that these lenses are ideally corrected for use with Mazda lamps and the new high-speed film.

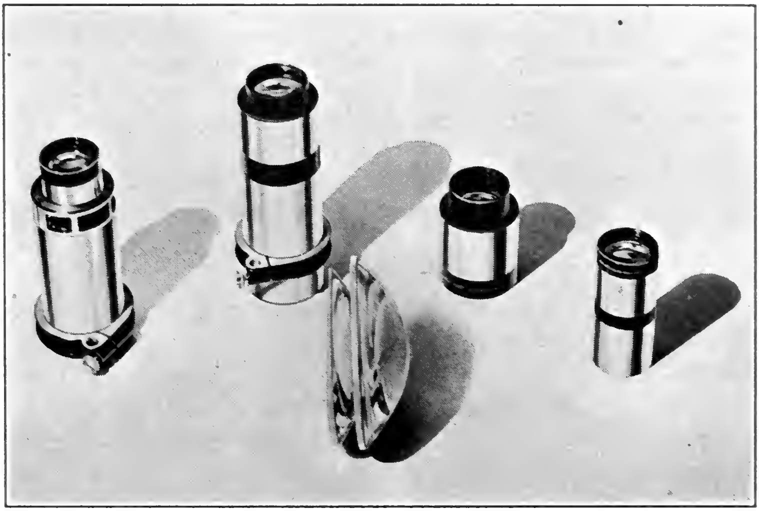

FIG. 22. Mounted super-cinephor lenses and cinephor condensers No. 5124 and No. 5125.

Super-Cinephor Projection Lenses.—These lenses are the first truly anastigmat projection lenses to be offered, and are notable for the quality of image—flatness of field, definition, and freedom from color fringes. They were developed to meet the anticipated demand for wide film, which would require lenses corrected for twice the angle compared to their use on 35 mm. film. More recently these have been developed in focal lengths down to 2 inches so that there is now available a series of short focal lengths for use with standard film that makes possible the projection of the large size picture now in vogue in many of the theaters with a quality of image heretofore impossible.

* Bausch & Lomb Optical Co., Rochester, N. Y.

Super-Cinephor Condensers.—These condensers have been specially developed for use with high intensity arcs producing from 50 to as much as 100 per cent increase in illumination with very uniform distribution over the entire field. The rear condenser of 5½-inch diameter has a rear surface of convex cylindrical form, and a front surface of parabolic form. The front lens of 6-inch diameter has had a meniscus rear surface and a parabolic front surface.

RECORDING ON SOUND STAGES WITH PORTABLE UNITS*

CHARLES FELSTEAD**

Summary.—*The use of portable and semi-portable sound recording equipment is gaining favor because these types provide much more flexible and economical arrangements than are possible with permanent installations. Some of the units are installed in trucks which can move from one location to the other with great facility. Other units employ portable monitors mounted on platforms which can be moved about the studio from stage to stage and are used in recording either with truck or permanent installations. The paper briefly discusses the advantages of the portable type of equipment.*

A few motion picture studios are now making considerable use of portable sound recording trucks in conjunction with specially constructed sound stages that are not equipped with permanent recording installations. When sound recording was first introduced the portable units were considered suitable only for use on location. Elaborate permanent recording channels were built to operate from the sound stages, and because of the high cost of the building necessary to house these permanent channels and the relatively large amount of apparatus that was required for them, the investment was truly enormous. It was soon realized that it would be far more practicable and less expensive to use portable sound trucks for recording on stages than to equip each stage with its own permanent installation. This arrangement proved to be a simple solution of the problem of reducing the cost of equipment, and in addition provided a more flexible recording system, as it left the sound trucks available for use on location when not needed at the studio.

The sound stages intended to be used with the portable recording units are generally somewhat smaller than those connected with the permanent installations. Usually several of these stages are built adjoining and massive sound-proofed doors are installed in the walls between adjacent stages. When it is necessary to build a large set, the doors are thrown open, converting the several smaller stages into

* Presented in the Symposium on Sound Recording at the Spring, 1931, Meeting at Hollywood, Calif.

** Universal Pictures Corporation.

a long stage great enough to permit the construction of very large sets. The doors are ordinarily kept closed in order to permit the

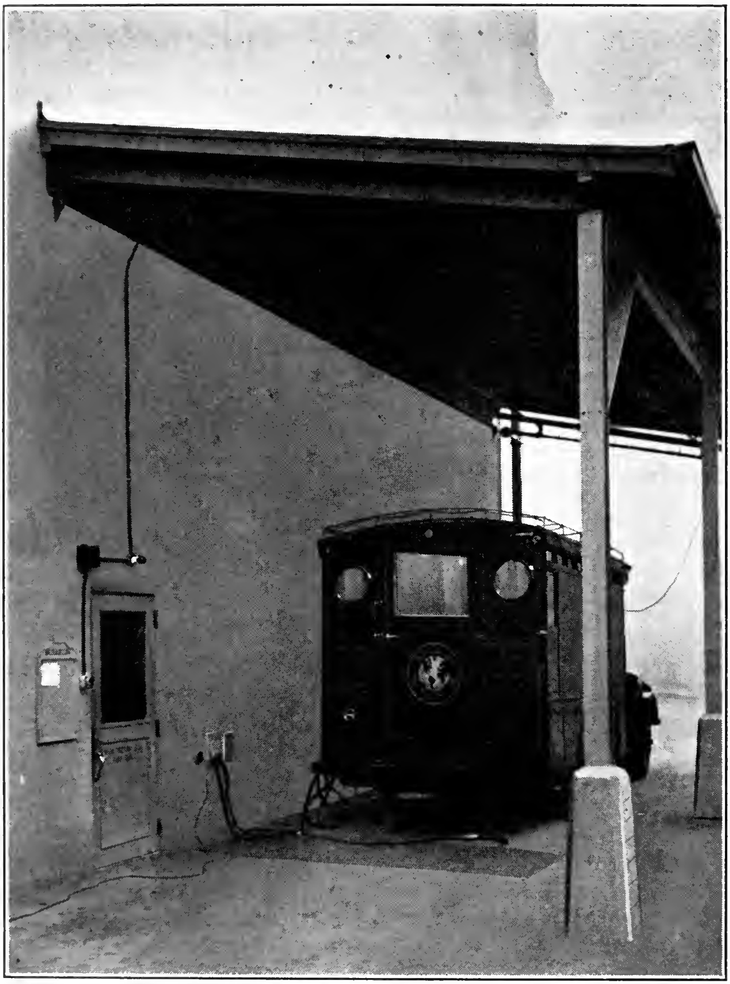

FIG. 1. A portable sound recording truck operated in connection with a sound stage. The cables connecting with the monitoring equipment inside the sound stage are plainly visible.

stages to be used individually by several smaller picture companies. The construction of the foundations, walls, and roofs of the stages follows standard practice in sound stage design. Special care is taken

in designing the walls and doors between stages to make them as sound proof as possible. They are generally made of double the usual thickness, with insulating blankets hung on both sides to furnish the required acoustic effects. A sloping roof built against the outside wall of each stage provides a shed for protecting the sound truck from the weather. Where several stages are located in a row, the sheds are all built on the same side of the stages so that the trucks can be shifted from one stage to another and to permit one man to take care of the charging of the batteries of all the trucks when they are not being employed for recording.

The cables for the monitoring equipment and for the motors that drive the cameras enter the stage through a small opening cut in the wall. The edges of this opening are heavily padded to prevent sound from going through. The usual portable monitoring equipment is generally employed for controlling the sound level at the input of the recording apparatus on the truck, but in some cases these stages are equipped with small movable monitoring booths or with permanent monitoring rooms built into the wall of the stage. These special monitoring booths and rooms are connected to the recording equipment on the sound truck by plugging the truck monitor cables into jacks built into the sides of them.

The trunk-like case in which the usual portable monitoring equipment is compactly arranged serves to protect the apparatus when it is being transported on the sound truck from one location to another. Two standard three-position mixing panels are mounted in the upper part of the monitoring trunk, permitting as many as six microphones to be employed at one time. The lower half of the trunk supports the control panel which carries the six special jacks into which the cables from the individual microphones are plugged. The main volume control, the volume indicator meter, the voltmeter for the filaments of the tubes in the condenser transmitter amplifiers, the six filament switches and the filament rheostat, and the two jacks for the cables that connect the monitoring equipment with the amplifiers and recording apparatus on the truck are also mounted on this panel. A single-stage booster amplifier is installed in the lower part of the trunk, equipped with a fixed filament resistor so that no adjustment of this amplifier is necessary. A special high-quality monitoring headset connected across the output of the recording amplifier in the truck is worn by the monitor man.

An improved form of semi-portable monitoring equipment which

has been used in the Universal Studios for several months has proved to be unusually convenient and satisfactory. Although this equipment is arranged so that it can be connected to the permanent recording channels, it is designed primarily for use on the special sound stages with portable recording units. It is sufficiently portable to be moved from stage to stage with ease but is not intended for use out of doors. The cabinet housing the equipment is of wood and resembles an old-style roll-top desk. A single three-dial mixing

FIG. 2. Semi-portable monitoring desk for stage recording.

panel is mounted in a sloping position inside the desk. Only one mixing panel is used as it has been found that it is very unusual for more than three microphones to be required at one time. The main volume control is placed to the right of the mixing panel, and the volume indicator meter just above it. The voltmeter and rheostat for regulating the filaments of the tubes in the microphone amplifiers are mounted in line with the volume indicator meter. Below them is

a plate of signal lights and an adjustable attenuator. The signal lights are operated when the desk monitoring equipment is connected to a permanent recording channel but buzzer signals on the intercommunicating telephone system are used for signaling when the equipment is employed as the mixer control for a portable truck. The attenuator is in the headset circuit, permitting the monitor man to adjust the sound in the headphones to a volume that he considers commensurate with the deflections of the volume indicator meter.

The three-stage booster amplifier, a small jack bay that permits various combinations of apparatus to be obtained by means of patch cords, and the jacks that receive the cables from the microphones and from the recording system are mounted in a recess in the side of the desk. Only three jacks for microphones are provided; but four jacks are provided for the cables that connect the monitoring equipment with the recording channel. Two of the latter are employed when the equipment is used with a permanent recording channel, the other two jacks being employed when a portable recording unit is in service. Two sets of connection jacks are needed on account of the different arrangements of the battery circuits in the permanent and portable recording channels. The storage battery that supplies the filament current to the tubes in the condenser transmitter amplifiers and the booster amplifier, and the dry batteries that furnish the plate potential for the tubes in the microphone amplifiers are placed in boxes beneath the monitoring desk. The desk and a chair are mounted on a platform equipped with wheels so that it can easily be moved about.

One of the advantages of the portable type of monitoring equipment is that it can be placed close to the microphones on the set, making the microphone leads short. Since the electrical level of the speech current is raised by the booster amplifier, the speech current that passes through the long transmission line from the monitoring equipment to the recording amplifiers on the sound truck will be at a much higher level than it would be if the monitoring apparatus and booster amplifier were situated in the sound truck. The ratio of signal to noise picked up by the line is therefore greater than it would be if the signal level in the transmission line were at a lower level.

A single portable recording unit equipped with a desk-type mixer control can take care of several sound stages. When a company that has been shooting on one stage has finished with the set, it can move to another stage where the next set has been prepared for it,

taking along the portable sound recording unit. With this arrangement, the production company does not have to wait until the first set is torn down and the next one erected in its place. Another advantage of the portable recording channels is that the sound truck equipment is much simpler and less likely to cause trouble than the permanent recording equipment. It occupies no ground space permanently, and a smaller crew of men is required for its operation and maintenance. By providing two crews to a truck, it can be employed for recording on one stage in the daytime and on another stage at night, thereby making the sound equipment do double duty. When a portable unit breaks down it is replaced in a few minutes by another truck and the shooting is continued with practically no delay and the defective unit is repaired by the engineering staff of the sound department at their leisure. This new arrangement is gradually supplanting the permanent recording channels for all recording work other than dubbing and the scoring of music, which are done on permanent channels and in special scoring stages.

It is likely that semi-portable sound equipment may soon almost entirely replace both permanent channels and the more cumbersome and expensive portable recording trucks used on the studio lot, as compact recording equipment is now being developed that is so light in weight that it can be placed on a small hand-truck and be easily moved about the studio. This new recording equipment has proved to be highly efficient and easy to handle despite its small size. The portable sound trucks will have to be retained, however, for use on location at points distant from the studio where rugged, readily-transportable equipment is required.

STANDARDIZATION OF THE PICTURE APERTURE AND THE CAMERA MOTOR—A NEEDED DEVELOPMENT*

FRED WESTERBERG**

Summary.—*This paper briefly discusses the need for standardization of the picture aperture of cameras and of camera motors. It is pointed out that great disadvantages arise through the use of freak or un-standard equipment, particularly with regard to the great variety of blimps now in use. The paper points out the necessity for standardizing the width of film and the width to height ratio of the picture, and for continually acquainting the cameraman in simple language with current progress in the art with relation to matters which involve the camera.*

Complications in the cinematographic process due to the adoption of talking pictures are in a sense inevitable, but certain phases of the new order having to do with the chaotic condition of the camera equipment call for remedial action. The cinematographer is certainly carrying too much baggage, and is wasting his efforts on too many details unrelated to the photographic process to be able to do his best work.

It is to be expected that as the scientific structure becomes more and more involved, the cinematographer should become more technical minded. There is no harm in this if it can be accomplished without affecting his practical outlook, and his sensibility and feeling for the artistic and dramatic which has such a great bearing on his work. For instance, much of the profound investigation in the higher reaches of the photographic art may be safely entrusted to those who specialize in research if they will but turn over to the cameraman in plain language any bits of practical information that they may find.

The complications that are giving rise to the greatest harm are those that revolve around the operation of the freak camera equipment now in use. At the root of this evil lies the lack of a standard aperture, as well as the lack of a standardized camera motor, which is

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Hollywood, Calif.

hampering, if not altogether checking the development of new silent cameras. Until this development takes place the whole array of queer camera blimps must continue to keep down the efficiency of the cameraman.

An attempt at determining a new standard aperture must, indeed, be possible at this time. The subject has been discussed at great length, and many solutions have been attempted. The lines are quite well drawn. The principal points to be considered are:

(1) Shall 35 mm. be retained as the standard international width of film? (2) Is the present sound track a fixture? (3) Should the 3 by 4 picture be retained as the international standard?

If all these questions must be answered in the affirmative, the result is a projection aperture substantially 0.600 by 0.800 inch and a negative aperture only slightly larger.

If the above questions can be successfully contested here and there, the way is open for an improved set-up. The cinematographer naturally wants the size and proportion of the picture that will give him the best technical and artistic advantage, but above all, he wants a definite settlement. Aside from clearing the decks for action in regard to new construction, he needs the assurance that his picture will reach the screen without changes in shape or size. At the present time the head-room is an unknown factor and to vignette would be suicide.

Progress, too, awaits the standardization of the camera motor. Due to the fact that the motor may have to be built into the camera in order to achieve the utmost quiet, every effort should be made to standardize at least the size of the motors, their speed, and their mounting, so that they can readily be interchanged for any system of recording.

DISCUSSION

MR. FEAR: The problem of camera motors goes somewhat further than simply the motor. A standardized motor that runs at a speed of 2,400 rpm. is not at all desirable for silent cameras. It is the elimination of gears and gearing that is the big problem in the silencing of cameras. If the producer would standardize on a frequency of 48 cycles he could then utilize motors which are available at the present time that run at 1,440 rpm. The Westinghouse E. & M. Co. is building an interlocking motor which is adaptable to either the 3-phase operation or interlock systems. If we could standardize on a frequency which would enable us to avoid gears, we could build the motor into the camera and produce a silent camera motor. Any camera manufacturer will be able to build silent cameras, once he has a standard motor and definitely knows that

that motor will be used. At the present time it is necessary to use an adapter for several different types of motors, all of which introduce complications, as they variously rotate at 1,200, 1,800, 2,400, and 3,600 rpm. It is impossible to make one adapter fit all conditions, with such a multiplicity of motors as are now being used. If a standard frequency is adopted we can build the camera motors into the cameras as an integral part of the camera, insulating them in such a way that they will not transmit noise, and thus be able to produce a camera which will not have to be used inside a booth.

MR. DUBRAY: The question of standardizing the aperture of the camera is very "hot" right now. The camera manufacturers are all working toward standardization, at least as far as is compatible with the commercial side of the problem. I understand that the present situation is rather complex—the Publix or Movietone apertures are not sufficiently used as yet in all theaters to unconditionally warrant establishing either of them as a standard. We hope that a decision will soon be made. Standardization is a slow process, and we can only hope that the existing conditions will improve and that the Publix aperture, retaining the old picture ratio of 3 to 4 (after allowing for the necessary width of sound track) will be established as a standard camera aperture.

MR. FEAR: As I understand it, the 35 mm. film is now standard. However, we cannot say it will remain standard indefinitely. If we change the film size, we should use a ratio that is esthetically correct, such as the 3 by 5 ratio, or any ratio the Society may decide upon. To limit ourselves at the present time to the 3 by 4 ratio for future development would be inopportune, I believe.

A NOTE ON THE NEED FOR RE-DESIGNING THE AUXILIARY CAMERA VIEW-FINDER*

FRIEND F. BAKER**

Summary.—*Due to the great variation in blimps or camera covers, it is impossible to standardize on auxiliary camera view-finders. At the present time these finders are so arranged that the finder picture coincides with the photographed picture in but one plane, so that the cameraman cannot depend on the finder picture for photographing the desired view. Several remedial suggestions are made in this paper, and the great expense caused by the lack of well-designed view-finders is briefly discussed.*

Have you ever asked a producer what the auxiliary view-finders are costing him on each production? What would be his reaction if he were told they were costing him more than all the camera equipment on the picture is worth? That would be a very broad statement; but let us study a few of the facts and then draw our conclusions.

First of all, just what is so entirely wrong with our present view-finders as to cause a great waste of time? The cause is an indirect one; the blimp, or camera cover, is the principal offender. There are few, if any, serious steps being taken to build a perfect finder for a camera housed in a blimp.

In the pre-sound days when the finder was directly connected to the camera it was bad enough to have to re-set it for each change of camera set-up, but now with the necessity of using a blimp, the situation is a serious handicap.

On most blimps the view-finder has been moved to the outside, making the perspective point far to the side of the photographing lens, so that the finder picture coincides with the photographed picture in but one plane. Finders mounted in this manner are usually very flimsy affairs, and cannot be trusted even under favorable circumstances. Some companies have favored the idea of building the blimp around the finder and camera combined, producing the monstrosity commonly known as the "bungalow."

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Hollywood, Calif.

A very desirable form of finder would be one built into the blimp as a permanent unit to fit the camera. Attempts along this line have been made by placing the finder lens about six inches directly above the photographic lens. This form, however, has a bad variable head-room, together with the very serious difficulty of being unable to shade off the blimp glass or photographing lens without cutting into the top of the finder picture. The only solution for this is to shade off with black flats far back in the set. Then with a three-camera set-up it becomes a problem to rearrange all the top lights to fit the shades.

Let us take any camera crew and watch them worry over the setting of finders. You will find it a very interesting procedure, as they do a lot of apparently unnecessary work over and over again, as often as the camera is set up. Even after all this painstaking work, the cameraman can only trust to luck that he is photographing what he sees in the view-finder. This procedure wastes valuable time—time that operates on the cost of production. The present equipment, with finders that are neither accurate nor dependable, must be carefully checked at the last minute before shooting, while the whole troupe waits.

From observations covering several camera crews at various studios, a very conservative estimate has been made which would charge directly to finder equipment at least forty minutes per day of production time. This is based on eight set-ups per day using two cameras. It does not include the many times per day that it is necessary with present equipment to throw over and look directly through the camera to check microphones, *etc.*

Consider forty minutes a day; a twenty-eight day picture; the salaries of the entire troupe and the cameraman.

Why not stop all this waste? A finder can surely be built that would have all the good features and none of the bad. It is only necessary to build one with the present upright, well illuminated field having the same perspective as the photographic lens, or within two inches of its axis. It should have a micrometer adjustment, visual footage indicator, and the same size field for all focal lengths. Such an instrument will allow instant adjustment and give the camera operator a full-field finder picture of the exact area being photographed.

That does not sound difficult, but consider how many kinds of cameras there are. Not many, true enough, but consider the great

variety of blimps. There are scarcely two alike. It is a case of an individual design job for each camera. Before we begin to re-design them we must agree upon a suitable model and standardize equipment to conform to it. Cameramen have studied this problem since the introduction of sound, and many of them have evolved constructive ideas. The S. M. P. E. or the Academy should appoint a group of such cameramen to work with the camera manufacturers to straighten out the situation.

DISCUSSION

MR. PALMER: In connection with this matter of the view-finder, I would like to suggest the obvious advantages of the old Debrie camera in which the image which was actually going to be photographed on the film could be seen directly through the back of the camera, not only while setting up the camera on the scene, but during the actual photographing of the scene itself.

MR. FEAR: I believe Mr. Baker has not sufficiently investigated the matter of the wide angle matte box. I believe the Mitchell Camera Company makes a wide matte box, and I know we make one that can be used on the standard camera.

The cameraman needs two types of camera—one for studio use and one for newsreel use. The newsreel type is highly desirable for recording when a camera is required for recording within the camera without separate recording means. The Western Electric Company has an adaptation of the Akeley movement in their design. The question of motors is not as serious, as we can furnish a silent motor, provided the studios will agree to use a standard frequency of 48 cycles.

THE CAMERA OF TOMORROW*

IRA B. HOKE**

***Summary.**—This paper deals primarily with the need for improving the design of cameras and camera accessories. Existing photographic equipment is reviewed and the inefficiency of blimps and camera covers is stressed. The remedy for the situation evidently lies in the standardization of motors and the adoption of silent movement cameras. The paper closes with a summary of views on the matter by leading first-cameramen of the industry, and suggestions for changes in existing accessories, to be embodied in cameras for the future.*

Since the advent of sound it has been evident to cameramen that something must eventually be done to provide modern photographic apparatus in order to cope economically with the radical changes brought about in studio production.

All cameramen in studio production are forced at present to work with out-of-date equipment. Much progress has been made within the past year, but that progress has been rather of a makeshift variety. Little actual constructive advance has been made in photographic apparatus since the pre-sound days.

Clumsy and cumbersome boxes have been built for shielding from the microphone the noisy cameras and motors, instead of directing that effort toward the perfection of mechanically silent equipment. Every day producers of motion pictures are losing thousands of dollars due to their reluctance to spend relatively small amounts for silencing and standardizing camera equipment.

At least two camera manufacturers have carried on extensive camera and motor silencing experiments on their own initiative to such an extent that they will be able within a few short months to begin wholesale production of suitable equipment. There is, however, one discouraging factor which they all face; that is, a standard motor.

It may be said that the number of different motors can almost be determined by enumerating the producing studios. It is evident that little progress will result from operating the finest silent

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camera movements by fair, noisy, or indifferent motors. It makes little difference which of the recognized standard systems is adopted, so long as producers unite their efforts toward the perfection of the selected unit. Camera manufacturers, of course, prefer a camera-speed motor as a nucleus.

The producer is inclined to figure that since he has spent thousands of dollars muffling the noise of old-fashioned cameras, his responsibility in the matter ceases. But not so.

Last March the Academy of Motion Picture Arts and Sciences sent out a questionnaire to first-cameramen engaged in production. Of the sixty questionnaires returned, 91 per cent advocated strong efforts toward the development of cameras which will require neither blimps nor covers. These cameramen represent every studio in Hollywood.

Ninety per cent condemned blimps or covers because of their weight and 87 per cent because of their bulk. Over 50 per cent stated that covers made focusing difficult. Practically every type of deadening device in Hollywood was criticized for one or more of these reasons. These are the opinions of the men who are close to the seat of the trouble. They all tell the same story—inefficiency, lost motion, untold valuable time sacrificed—in order to salvage antique equipment.

The time has come when cameramen must insist on more efficient equipment, and the producer must see that the camera manufacturers provide it.

This patently requires a total revision of existing cameras, and we should be certain of our steps before we proceed. For instance, if we should merely remodel the present camera, we would find ourselves struggling again with un-standardized details, small gadgets not usually thought of as essentials, but great time savers or time wasters, as the case may be. Let us, therefore, itemize a few of the lesser details which should not be overlooked in our quest for silent movements and noiseless motors.

Movements should, of course, provide register pins, a convenient cleaning arrangement, and positive roller contact. A standard aperture should be agreed upon and suitable masks provided and used, so that only the composition originally made by the cameraman could be projected. This is, in itself, a simple matter, as there are required only an aperture mask for the camera and a similar one for the projection machine. At present, various cameramen are framing for Movietone, Academy Standard, and full-screen proportions. It is

evident that projectionists are at times unable to present the picture as originally composed by the cameraman. Here, again, is an example where only the producers can help themselves. It is a case of agreement on standard only.

A combination buckle trip switch, instantly adaptable to either synchronous or non-synchronous motors, will save untold time and repair expense. This trip is a device which throws a sensitive switch the instant the film fails to take up properly after being exposed. Buckle trips now in use break the motor contact before six inches of film are out of place, the camera stops, and severe damage is avoided.

Multiple-length dissolve mechanisms are features of almost every camera and by all means should be retained.

In order to compensate for the weight added by integral motors as well as the extra weight necessary in the modern wide aperture lenses, it has been suggested, wisely, that the quadruple lens turret be eliminated in favor of a light frontboard provided with a quick-acting quadruple screw-thread. The base of each lens mount would embody a companion screw-thread to fit accurately in place on the frontboard with a two- or three-turn movement. This arrangement would allow a more rapid change of lenses, a more positive and rigid lens base, and would also enable the cameraman to rapidly select any focal length desired without encumbering his camera with heavy equipment only occasionally used.

Then comes the question of more careful selection of lenses. At least one company has employed a widely experienced lens expert who makes photographic tests of every lens purchased by the company before it goes into actual use. He is certain that each lens is optically efficient for use in the modern motion picture studio.

Optical systems providing for eye focus and line-up of photographic composition, are at present highly perfected. However, the view-finder, through which the action is watched by the cameraman during actual takes, is due for improvement. The best of these in use today is separated by several inches from the axis of the photographing objectives, thus rendering a correct view of the composition at only one distance from the camera. These finders are provided with a single lens. The field of view changes rapidly with change of focal length of photographing lenses, and this is compensated for in the view-finder by a series of mats with an opening to correspond to the field of the lens being used. On the face this appears satisfactory, but in the case of long focal length lenses, where greatest accuracy is required,

the field of view becomes too small. Such finders would profit materially by a wider range of objectives in order to provide a larger image on the working ground glass when 4-, 5-, and 6-inch lenses are being used on the camera. One cameraman has provided himself with a separate finder embodying this principle, for use with lenses having focal lengths greater than 50 mm. He has fitted this finder with a $6^1/_2$-inch lens which allows large aperture mats to be used when the longer focal lengths are used.

The ideal method of watching the picture during the take would be, of course, by means of a reflected image taken directly from the photographing lens. Several manufacturers have seriously considered this step, and in the case of one studio a wide gauge camera was built last year successfully applying this feature.

Mat boxes, or sunshades, have in the past, and do today, lack versatility. That is, in order to use the wider angle lenses on the camera the operator must entirely remove the device in order to prevent its sides from cutting into the edges of the scene. The remedy for this is simple and of no moment mechanically. It entails merely a larger model of the present design. Several cameramen have built their own models successfully, but at present no manufacturer provides such a unit.

A few weeks ago an enterprising inventor startled the industry by embodying in his late model camera a built-in automatic exposure meter. The camera of the future should without fail incorporate such an instrument. The efficacy of a completely automatic meter is unquestioned.

Two companies have produced gyroscopic tripod heads which are of inestimable value in panorama and close-up shots. These tripod heads allow the cameraman a smooth, easy, floating control of his picture composition at all times and under all circumstances. Scenes made with the gyro tripod tops are noticeable on the screen by their liquid moves in framing up or down for head room and for their easy allowance to actors of a natural freedom of side movements on large close-ups.

These are but a few suggestions of details necessary in the camera of tomorrow. Today's camera is a hodge-podge of mechanical gadgets that have been screwed on in convenient places. It has been a good camera for us to learn with, but now that we know what is necessary to photograph successfully the modern screen play we must discard our beginner's tools and build an instrument worthy

of the greatest era yet to be witnessed in the amazing growth of the cinema—tomorrow.

Before the change-over of cameras is made by the producing studios it is, therefore, advisable to appoint a committee of recognized first-cameramen to pool their ideas of mechanical features to be adopted in the new instrument. If such procedure is followed the manufacturers will be enabled to standardize cameras that will stand the test of efficient service for many years.

PROBLEMS OF THE CAMERAMAN*

LEWIS W. PHYSIOC**

Summary.—*A historical introduction, outlining the various stages of development of motion picture photography; progress in the manufacture of materials; innovations in technic; changes in the design of equipment, lighting systems, etc. The present school of photography is facing a most unsatisfactory period, with its excessive amount of interior work and elaboration; the art is developing too rapidly to permit cinematographers to thoroughly master it. Great restraints are placed upon the cameraman by the recording of sound, and the camera covers are a serious handicap to his artistry. The supersensitive film gives promise of an era of better photography, permitting improvements in exposures and lighting system The use of filters is but imperfectly understood by the cameraman; and motors, apertures, etc., must be standardized before any considerable improvements in camera design can be realized. The need for photometric devices and other scientific measuring instruments is emphasized, the lack of such facilities causing a degeneration of the photographic art to a system of guesswork.*

Many students of the various forms of art have considered it a good method of study to review particular periods of development, search out the secrets of individual mastery, and classify definite schools of treatment. Such a course of study may aid in the solution of the current problems of a like art. The acknowledged merits of one example may point out the errors in another. A thorough analysis of these merits may furnish ideas that the student may apply to his present study, from these ideas developing new ones, suggesting new needs, and acquiring a greater degree of perfection in his art.

When we speak of the student we refer to the type of mind that leaves nothing unturned that might add to his enlightenment. Let us not fear, then, to go back to the daguerreotype or the wet plate, even if these do nothing more than to inspire a just appreciation of the photographic materials and facilities in use today.

But what is more important, we may find in such a retrospect much evidence of sufficient merit to show very clearly the magnitude of the responsibility that devolves upon the cinematographer of the

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present time. This evidence becomes very significant when we enumerate the comparisons between modern materials, equipment, and facilities, and those of former times. In such a survey we take no notice of that early period when the mere novelty of motion pictures excused and permitted all kinds of photographic efforts. We rather consider the beginning of the post-war period, when motion picture photography developed into a really beautiful art. It may be interesting to review some of the agencies of this development.

Some of the pioneers were beginning to learn the powers of their medium. The very beauty of the thing was beginning to enlist fine talent peculiarly fitted for the art. Contributions made by one class of investigators stimulated others. Projection was improved; the laboratories moved from dirty sheds and cellars into handsome buildings equipped for better processing. The manufacturers responded with improved cameras, new and varied lenses; the old static-generating film was replaced by the X back and, shortly after, that was improved. The open air, diffused sunlight stages gave way to inclosed ones with their limitless combinations of artificial light. Directors and cameramen, alike, enjoyed the full range of their medium. The pictures abounded with beautiful outdoor scenes and spectacular light effects. The industry prospered and offered generous encouragement to the most earnest efforts toward artistic developments. All this resulted in that period of interest which we are now considering.

It was likewise a period of experimentation. Everyone experimented, and the results were astounding. Novelties were introduced with breath-taking swiftness. Successful experimentation furnishes the most stimulating influence on the mind of man, and urges him to achieve still more. Nothing stops him except the inviolable laws of nature.

All these developments so broadened the cameraman's means of expression that he began to exhibit a definite individuality. He had become an artist; his manner of vignetting, his system of lighting, his soft focus effects, his exterior compositions were thoroughly characteristic.

Still he was not satisfied. He wanted to do things yet denied him—to go into shadowy places which his 4.5 Heliar had heretofore prohibited; to produce more satisfactory night effects; to photograph the clouds hanging over the mountains; to render color in proportion

to its effect on the eyes. He had to have faster lenses, and highly sensitive panchromatic film.

THE NEW SCHOOL OF PHOTOGRAPHY

The acquisition of these new, or improved, elements ushered in a new style of photography, and for the next few years, according to some critics, motion picture photography appeared to be less satisfactory than at any time since the early stages of its development.

The reasons for this condition are worthy of study. There developed a great tendency to shoot pictures on the lot or on interior settings, and as a result the pictures lost their charming variety of interplay between beautiful exteriors and adequate interiors. Simple beauty and tasteful elegance were submerged in competitive display and elaboration, and in complicated photographic effects.

The new wide aperture lenses were difficult to manipulate. There was a considerable amount of faulty focusing, from which developed a careless distinction between the legitimate diffused effects and real errors of focus. The broad-faced lenses were also difficult to mask, and tended to flare and veil the image.

There developed a marked tendency to overexpose, in order to secure "softness"—an exaggerated use of shiny reflectors on exteriors and too much front light on interiors, neutralizing the effect of the principal sources of light, as of special accents.

This tendency required an appropriate modification of laboratory treatment. Although developing formulas were greatly modified, nothing more was done than to provide printing densities by superficial development. In many cases the entire printing systems had to be changed. All these changes, it is reasonable to suppose, may have developed an entirely new taste for, or judgment of, quality; this we can determine only by a review or comparison of past performances.

All this may appear critical, but we can reasonably plead extenuations in the matter. We have developed too rapidly. The cameraman had advanced to a higher state before enjoying, for a while, his mastery of current conditions—seeking innovations before exhausting the existing novelties.

A great financier in analyzing production problems has said that twenty-five years should have elapsed before giving us the panchromatic film, fifty years before giving us the color pictures, and a hundred years before giving us the talkies. But to return to our alibis:

Picture production was becoming an elaborate display. There is nothing which frightens the rank and file of workers so much as the responsibility of spending vast sums of their employers' money. Retakes are costly, the time of making them is more so. There is a temptation to insure one's position by using every available element of the process of making pictures.

The introduction of the panchromatic film and incandescent lighting staked out a new milestone on the road of progress of the art. They demanded more of the cameraman's skill. They brought him face to face with a deep and complicated branch of science from which he was heretofore exempt—the theory of color. Many able photographers freely expressed their uneasiness over this new phase of their profession. Others welcomed the new system with bold assurance; and some achieved such success as to prove, beyond a doubt, the value of the new material.

In bringing our retrospect up to date, we believe that there is still a tendency to overexpose. Photometric readings have been made in various laboratories that disclose the fact that the great majority of negatives, both exterior and interior, are printing on the heavy side. And what is more important, the negatives do not have the appearance of being fully developed, leading to the belief that the machines and developers have been adjusted to secure a printing density at a sacrifice of quality. There have even been instances where it was necessary to dupe negatives in order to print them.

The dupe furnishes another reason for what may appear to be a hypercritical attitude. A dupe is a dupe, no matter how well made; and the amount of duping done in the last few years cannot but have shown its effect on the general quality of the pictures. All this may suggest that we were beginning to stray from the first principles of photography, *i. e., correct exposure and proper development.*

THE INTRODUCTION OF SOUND

Before we had completely mastered these difficulties, talking pictures were upon us. They greatly affected the photography of motion pictures for very apparent reasons. The cameraman no longer has the freedom and the range of activity he enjoyed prior to the sound picture. He has had to make the best of the sound-proof booth and the various other camera covers. These adjuncts have restricted his individuality and have shrouded his artistry in a mattress—like requiring a violinist to play with mittens covering his sensitive fingers.

There is a very unsatisfactory feeling in having to shoot through heavy plate glass, with its refraction and reflection, the personal discomfort of the cameraman, the difficulty of lining up sets and focusing, or following focus during the moving shots that seem to have become so popular.

Many inquiries have been made as to what type of blimp is most satisfactory. There are no satisfactory blimps. Indeed, there is little improvement in the "blimp" over the "dog house" (booth) of the earlier days of the talkies.

THE NEW SUPERSENSITIVE FILM

We now approach still another era in motion picture photography—the era of the supersensitive film. The new film seems to have found favor among the cameramen. The reasons are interesting, and an analysis of those reasons should be helpful.

Exposure.—We cannot be too insistent upon a correct exposure, and a study of this particular situation discloses a very encouraging outlook. In some quarters where there has been a tendency toward overexposing, the work shows a decided improvement. The reason for this lies in the fact that the operator, knowing the great speed of the film, loses some of his fear of underexposing. He is lighting the sets more softly and is no longer afraid of shadows; and shadows well arranged are the life of photography. Many have returned to the $f/3.5$ aperture on the studio sets, which furnishes better definition and improves the focal effects obtained when moving objects are included in a background of close-ups. All this has likewise improved the printing range.

Filters.—It is yet too early to consider the question of filters in connection with the new supersensitive film; here again we can study this subject only by reviewing past usages.

After having canvassed a number of cameramen, we have come to the conclusion that considerable uneasiness is felt regarding the use of filters. There is, apparently, a limited understanding of this complex subject. Many complain that the information given out by authorities is too technical in character for the majority to understand thoroughly.

Some have successfully used the neutral filters for controlling exterior exposures, but they rarely go beyond the use of the 50 per cent filter; some have used the combination of the neutral and the color separators; some, who are very timid as to the use of filters at

all, have confined their use to the great favorite combination, 23A and 56, for night effects.

Others have a most complicated collection of filters, and use them very indiscriminately. We may fancy that there is great danger of having too great a variety of contrasts in their work. Among such a collection are numerous "trick" filters, graduated from a highly actinic violet at the bottom to a deep mixture, such as the 23A and 56, at the top. Such a filter is supposed to render night effects, the upper part "holding down" the sky, while the lower part permits the foreground to register very definitely.

We question the value of such a filter; its effects are false and are lacking in natural balance. Indeed, it is very difficult to obtain satisfactory night effects in full daylight. It seems that very little improvement has been made in this matter over the former method of carefully exposing the panchromatic film with a uniform filter and submitting the print to the tinting and toning process. Some beautiful effects have been achieved by this old-fashioned method.

The knowledge of filters seems to be somewhat of a club affair. Cameramen like to discuss the use of this or that filter for various effects. The study of the subject seems to be limited to discussing the results of every-day experiences, and conditions are so variable from day to day and hour to hour that we doubt whether this is the proper method of study. The writer confesses that he is familiar with very few of the names of the various filters, but is accustomed to select a filter by judging it according to the prevailing light conditions, the name be what it may.

There are many difficulties that enter into the use of filters. There is a physiological variation among individuals' eyes. They do not see or judge color alike. Consequently, this exchange of experiences is readily accounted for.

It is generally agreed that best results are obtained by using filters as follows: For early morning light, up to 10 o'clock, use the K2 filter. For early morning back light, use K1, modeling and obtaining contrast by means of reflectors. For flat front light use K3, in order to increase modeling and contrast. From 10 A.M. to 2 P.M. use K1 with neutral and more exposure, in order to soften the shadows of the midday sun. In such light the color factor is least considerable, and the neutral prevents the veiling of the shadows so undesirable in exteriors. The neutral seems also to permit obtaining good luminosity and fine detail in the shadows, and prevents clogging up and

spreading of the highlights. From 2 P.M. through the afternoon, the color of the light of declining day is very noticeable and changes rapidly. In such light very little correction by filters is necessary.

Soft diffused sunlight is highly actinic and very tricky. It lacks contrast, and in such light colors are more pronounced. Such light requires about a K3 filter for color rendition and contrast. Spectacular cloud effects, of course, require a variety of treatment according to formations and the distribution of colors. This matter is independent of the foregoing suggestions.

The judging of the color of light is very difficult for those who are not particularly trained for such work. The artist must of necessity cultivate this. By estimating the color of the shadows he can determine the character of the light by the principle of complementary colors, which establishes the key in which he must paint his picture.

Those who are not familiar with the theory of complementary colors may be interested in a few simple experiments. Cover a desk lamp with a piece of red gelatin and permit the shadow of a pencil to be cast upon a sheet of white paper. The shadow will be a pronounced green, the exact complement of the red in the gelatin. Replace the red by blue gelatin, and the shadow will be yellow, complementary to the blue. The K3 filter, covering the light, will cast a shadow which is decidedly violet. Therefore, when violet or bluish shadows cross the foreground very little filtering is needed.

The neutral filters are very valuable, for in many instances it is very difficult to control the exposure without them, especially when the photographer dislikes the wiry sharpness of the diaphragmed lens. With filters, as with painting, we recommend a simple palette, K1, K2, and K3, and the 23A and 56. Some photographers seem to think that the new film gives best results with Aerial 1 and 2, the monochrome orange, and 23A and 56.

Lighting.—Since the introduction of the supersensitive film there has been a great deal of discussion as to its influence on the amount of light used on the sets. Investigation discloses varying conditions. There has been very little reduction of current for lighting. It is rather early to expect that. However, there has been a great deal of silking of the lights, which has invited some controversy. But it must be considered that the silking of the lights is not done for the purpose of reducing the light in lieu of saving electric power, but to increase the diffusion as well as to modify the exposure.

Highly diffused light permits a fine registration of special effects, such as lamps, lights through windows, *etc.*—the so-called trick lighting effects.

Some operators are giving the lights greater range, achieving greater dispersion in a slightly different manner from that obtained by silking, and allowing greater freedom of action and more personal comfort for the actors.

There are some who have probably expected too much from the new film and have made the lighting somewhat too sketchy. However, this is merely an experimental daring that soon will be corrected.

We have no doubt but that there will be great changes wrought in the lighting system; there is no question that there ought to be. Everything should be considered that may enable us to take full advantage of the merits of the new film stock—lighting, lenses, filters, developers, *etc.*

Make-Up.—Investigation shows that there has been very little change in make-up to meet the conditions of the new stock. There is no apparent reason why there should be any great changes, excepting those required to correct some of the errors of the past. Some of our best experts have always opposed straying too far from nature. Let the make-up rather serve the purpose of the retouch artist. There is still a great deal of exaggeration in the treatment of eyes and lips. The greatest of care should be shown in the treatment of pronounced blondes. There is something very false and unnatural, especially in black-and-white photography, when a very light blonde is shown with too swarthy a face, heavily shaded eyes, and harshly penciled lips.

The Camera.—Ever since the introduction of talking pictures the camera has been the cause of our greatest problems. The microphone, searching and exacting, turned out to be something the camera designers had not anticipated. The multitude of gears and moving parts make the present cameras very unfit for photographing electrically recorded pictures. A great deal of credit should be given those who have rebuilt them in an effort to silence them sufficiently. However, these alterations are merely heroic makeshifts. The increased speed at which they are driven is very trying on them. An entirely new idea is necessary. We believe that something already has been accomplished in this direction, a camera somewhat on the principle of the old Vanoscope, but not yet fully proved.

Motors.—The question of motors has been a serious one. They must be standardized before the engineers can make up their minds what to do about the camera. At present the personnel of each studio seems to have its own ideas about the type of motor to use. Another difficulty in the way of camera developments is the uncertainty of the picture aperture. This must also be settled before anything can be done.

The Aperture.—The present picture dimensions cause considerable worry for the artist. It is very difficult to frame a good picture in the present aperture with its awkward proportions. Vignetting and other effects are prohibited by the limited areas. Projection apertures are not standardized, and the cameraman is never sure of his frame. We frequently see the tops of heads cut off, actors partly out of the picture, and other awkward instances of framing.

The tremendous cost of providing a new aperture is realized, but the present one is certainly unsatisfactory. Even when matted down to the original shape, it has many disadvantages, chief among which is the apparent increase of graininess by further enlargement.

Photometers.—Obtaining the proper exposure is of such vital importance that a finely perfected exposure meter would be of great help. Heretofore it has been difficult to interest cinematographers in such a device, but the cameraman's responsibilities have increased to such an extent that they would now welcome anything that will aid them in estimating exposures. Such a device would enable the cinematographer to devote more time to the purely artistic features of his picture.

Spectroscope.—There has been an interesting attempt to design a spectroscope to aid in the selection of filters, but the experiment has not been carried far enough. This is probably due to the designer's lack of knowledge of the cameraman's needs. A slide has been provided into which a filter may be inserted, to furnish by this means a comparison of the spectrum with and without the filter. However, a very keen judge is required to determine how much and what portion of the spectrum is modified.

If such an instrument could be elaborated to furnish a scale that would show clearly the shifting of the bands of color and the varying character of the light, the operator might be enabled to choose a filter of the proper factor to compensate for the quality of light.

Standardization.—Photography has long been an art which has depended to a great extent on one's personal judgment, experience,

inherent impulse, guesswork, *etc.* The attainment of success has been in proportion to the individual ability of the operator to balance against each other a great many very uncertain elements. The operator chooses his subject, sets up his instrument, and muses: "Well, I guess I'll close the diaphragm on this to carry that distance, but to prevent too much harshness I'll give it a good, full exposure. Then I guess I'll develop in pyro, and strive for a soft, thin negative with lots of detail in the shadows." When the time arrives for printing he guesses through another process, and when it is finished exhibits a marvelous piece of guesswork.

Such efforts represent a highly individualistic art. But the making of motion pictures is a business which involves enormous expenditures. Nevertheless, the cameraman has to go through very much the same procedure as the lone artist just pictured; not, however, with the same limited expense of the still-picture enthusiast, but with thousands and thousands of feet of costly film.

The uncertainty of his endeavors is further reflected in the laboratory situation. The laboratory expert, in turn, follows with the guess that the developing machine should be run at such-and-such speed, using the accepted formula; he is sure of but one element, and that is that the correct temperature is 65 degrees.

We are trying to avoid overexposure and superficial development, and their accompanying gray and muddy tones. We must avoid underexposure and forced development, with their concomitant chalky whites and empty black shadows. We would like to know what are the ideal conditions, the full possibilities.

There may be possibilities in our present materials not yet explored. We would like to see experiments conducted to ascertain the full scope of the new supersensitive film, and for the purpose of establishing standards that will enable us at all times and under all conditions to get the best results without too much guesswork.

We do not know of another industry of such magnitude that so little encourages scientific research for the benefit of its technical departments. We cannot overlook the fact that we have learned a great deal from our brother workers in the sound department. They have well proved that with their more nearly standard exposures they can equally maintain or control the proper contrast in development.

What we need very badly is honest, intelligent, constructive criticism. There is nothing so stimulating as criticism; not the

caustic, controversial criticism so common among reviewers, but competent, analytical disquisitions. We have very little of this. A picture is either a "knock out" or a "flop;" the photography is either good or bad, dull or clear. We want to know *why* a thing is good or bad. We want to know what to avoid and what to enlarge upon. Some of us may not relish criticism of our work, but secretly we will profit by it, for the real student will gather from every source. An artist once bitterly upbraided an associate for pointing out an error on his canvas, but the more he tried to justify his work the more glaring that fault became, and he never rested until he had painted it out and corrected it.

BANQUET SPEECHES

PRESENTED AT THE SEMI-ANNUAL BANQUET OF THE SOCIETY, HELD AT THE HOTEL ROOSEVELT, HOLLYWOOD, CALIF., MAY 27, 1931

PRESIDENT CRABTREE: I wish, first of all, to extend a hearty greeting to all of you from the members of the Society of Motion Picture Engineers throughout the world; also, on behalf of the visiting members of our Society, I wish to thank those who have worked so hard to make our Convention such an outstanding success. We have been overwhelmed by your hospitality, which I assure you is deeply appreciated.

It was almost exactly three years ago that we held a meeting in Hollywood. By looking back and comparing our status then and now, we realize how our Society has grown, not only in size, but in its value to the industry and to mankind. The comparison also brings home to us the magnitude of the changes which have taken place in the technic of producing motion pictures.

In 1927 the tools of production consisted largely of cameras using orthochromatic film and arc lamps. The year following, panchromatic film was almost universally adopted and, in consequence of the improvements in photographic quality which resulted, the producers began to direct more attention to the technician because they saw that he also was a potential contributor to box-office values.

A study of the relative merits of arc and tungsten lamps for lighting sets was instigated by the American Society of Cinematographers and the Academy of Motion Picture Arts and Sciences, and these experiments were concluded just previous to the Hollywood meeting. The use of sound in conjunction with the motion picture was just beginning to be discussed, but with many misgivings. Our Society staged the first demonstration of Photophone equipment in Hollywood, but this attracted but slight attention from the producers. Six months later the sound revolution commenced. There was a mad scramble to build new stages and to modify old ones, and within a relatively short period of time there was an influx of a large army of skilled technicians to take care of the new equipment and procedure.

In the short space of three years remarkable advances have been made in the technic of recording sound and in the making of motion pictures, and it is, therefore, fitting that we should hold a national meeting in this center of production in order to exchange ideas and to discuss our new problems and recent researches.

But during these three years our Society has grown accordingly. For the benefit of those who are not well acquainted with our Society, it is a scientific organization patterned along the lines of many of the older scientific societies and serves as a stimulating, collecting, and coördinating medium for the technical and scientific knowledge appertaining to the motion picture industry.

Our membership of about eight hundred, which is distributed among eighteen different countries throughout the world, is as diversified as the various arts and sciences which serve the industry and includes research scientists from the universities and industrial research laboratories and theaters, and executives from all branches of the industry.

Eligibility for membership is determined by the Board of Governors, which has interpreted the word "engineer" to apply to anyone who contributes to the building of a motion picture, so that those who contribute literary, dramatic, and artistic talent are equally as eligible as those who direct the business of production and exhibition of motion pictures.

Membership is of four types: Associate, Active, Sustaining, and Honorary. Any one who is interested in motion pictures is eligible for Associate membership. Active membership is granted to those who have gained distinction in their particular field of endeavor. Sustaining members are those who contribute substantially to the support of the Society, while Honorary membership has been granted those scientists of international fame who, by their inventions and achievements, have been largely responsible for the building of this industry.

Conventions of our Society are held semi-annually and the various scientific papers and committee reports presented at the technical sessions, together with the discussions resulting therefrom, are published in the JOURNAL of the Society, issued monthly. In addition, the JOURNAL contains contributed papers, abstracts of current technical literature, patent abstracts, translations of outstanding articles appearing in foreign technical publications, reports of committee activities, and book reviews. During the year 1930, 1,500 pages of

scientific data were published, including over 100 technical papers dealing with the various aspects of production and exhibition.

The Society's *Transactions*, which were published quarterly from the year 1916 to 1929, together with the JOURNAL of the Society published since January, 1930, constitute the most comprehensive source of motion picture technical information in the world. The potential value of this knowledge to the industry is incalculable and the actual cost of the research work required to obtain it amounts to millions of dollars. The JOURNAL of the Society is distributed *gratis* to members but is available to non-members by subscription.

The Society maintains local sections with headquarters in New York, Chicago, and Hollywood, which foster a spirit of coöperation among the members who cannot always attend the semi-annual conventions. The Hollywood section keeps the parent body in touch with activities on the West Coast and maintains contacts with the Academy of Motion Picture Arts and Sciences.

It is through the medium of the committees that the Society best serves the industry in a coöperative and coördinating capacity. The bi-annual report of the Progress Committee gives, in condensed form, the essential technical developments in the fields of production, distribution, and exhibition throughout the world.

The Standards Committee has facilitated the interchange of the essential parts of apparatus throughout the industry and has published details of these in booklet form in collaboration with the American Standards Association. The Society has also collaborated with the British, French, and German technical societies on matters relating to standards.

Other committees of the Society have dealt with progress in color, methods of securing better sound recording and reproduction, and improved methods of studio lighting, while the Historical Committee has prepared reports on the accomplishments of the industry's pioneers and is assembling historical apparatus which will be placed in a suitable depository.

The subject of projection has been given special attention by the Projection Practice, Projection Theory, and Projection Screens Committees and, as a result of their efforts, recommendations for standard layouts of projection rooms of various sizes have been made and data secured for formulating a tentative standard for screen brightness.

The past year has also been conspicuous by virtue of increased activity of the Society in relation to collaboration with other organiza-

tions and societies having interests related to our own. The Society has acquired membership in the American Standards Association which has recognized the various standards adopted by the Society, and also in the National Fire Protection Association which has invited the Society to collaborate with regard to safety measures in the handling of nitrocellulose film. Contacts have been made with the American Institute of Architects with a view to collaboration in the design of theaters, particularly with regard to projection and acoustical requirements.

The Society will be officially represented at the 1931 International Congress of Photography in Dresden and arrangements for the exchange of technical manuscripts have been made with the Deutsche Kinotechnische Gesellschaft, which has also conferred Honorary membership upon the Presidency of our Society.

The need for education in the fundamental principles of science as related to motion picture technology has also been recognized, and, as a result of encouragement by the S. M. P. E., the Massachusetts Institute of Technology has laid out a special four-year course of instruction for those who wish to enter the technical phases of the motion picture industry.

It has been suggested that possibly there is some duplication of effort on the part of the S. M. P. E. and the Academy. The Technicians Branch of the Academy is likewise composed of scientists and technicians whose activities are devoted to education of the industry's personnel, the publication of technical knowledge, the standardization of practices, and the directing of coöperative research, but its interests to date have been focused largely on problems relating to the application to the production of motion pictures of the tools which the engineer has devised; while the S. M. P. E. has been concerned, not only with the fundamental principles of science, but with the devising and making of the tools of the industry and with finding improved methods of their application.

There is adequate room for all technical organizations in this great industry. One organization cannot give adequate attention to all the technical phases involved; and, on the other hand, the greatest benefit is often derived when two investigators tackle a problem independently—they often see the problem from different angles, and their combined researches tend to constitute a more complete solution of the problem. However, we must coöperate closely and without rivalry. Each organization should draw attention to the publica-

tions of the other. The S. M. P. E. has paved the way by devoting a section of its JOURNAL to technical activities of the Academy. We shall be glad to circulate with our JOURNAL any information relating to publications of the Academy—it is our duty to disseminate knowledge—the matter as to when, or where, or how the knowledge originated is immaterial.

There must also be the closest coöperation between committees of the various technical organizations in the industry, especially those dealing with the standardization of practices.

But how can you producers and your executives be of assistance to our Society? By taking an interest in technical matters—by encouraging your men to keep posted on the latest technical developments as published in our JOURNAL—by urging them to attend conventions and sectional meetings, and to take an active part in the discussions—and by allowing them to spend some portion of their working time in the interests of the Society. At these meetings they will make new friends and get new ideas. The importance of cooperation was never so great as at the present time. The day is gone when we can depend on the genius in the garret for discoveries—nowadays they result from the combined efforts of many workers. The future of your business depends on your man power—you owe it to your men to help educate them, and they, in turn, must sort out the information which can be applied to your own individual problems. You can also help by taking out sustaining memberships in our Society. A thousand dollars spent in this way will be returned to you a hundred-fold by virtue of increased knowledge and elimination of duplication of effort.

I think no one will deny that the engineer is destined to play an increasingly important part in this great industry; and the producer will have to depend to an increasing extent on the engineer to add novelty to his presentations. It is doubtful if there will be epoch-making engineering developments in the immediate future as revolutionary as the introduction of sound. The developments will probably be in the nature of improvements in quality both of black-and-white and colored pictures and of the sound, but these improvements will only be effected by paying the closest attention to minute details. There is hard work ahead.

The quality of the sound as reproduced in conjunction with the motion picture must be improved if the public is to remain entertained. The reproduction of speech is very satisfactory, but that of

music, as encountered in a very large proportion of theaters throughout the country, leaves much to be desired. There are serious leakages from the bucket of sound quality in the transfer from recorder—to laboratory—to projector—to loud speaker—and these must be reduced to a minimum. This can be accomplished only by research and education of personnel all along the line.

If I were a producer, before participating in the threatened revival of musicals, I should pay a great deal of attention to the subject of projection. Most producers are likewise exhibitors and realize that it is foolish to spend millions on a production and have the artistry of the picture destroyed by imperfect projection. The projectionist is one of the most important cogs in the complex motion picture mechanism, and he should be encouraged and educated.

In order to reproduce sound with a more perfect degree of realism, we engineers must extend the frequency and volume range of the reproduced sound, reduce ground noise still further, and add sound perspective. Recent researches have shown that the sound energy produced from a symphonic orchestra of only moderate size may be as much as 50 watts during the louder passages, which would require from 100 to 200 watts of undistorted power from the amplifying apparatus. When we consider that many of the existing sound installations are capable of handling only a maximum of 10 watts, it is realized that newer and more powerful equipment will eventually be required to give the public the degree of realism which it demands.

I think that in the future, the industry can expect a continued series of technical developments from the engineer such as have characterized the past few years. The application of these will require increasing expenditures if entertainment is to be forthcoming which is better than that which the radio and the home movie can provide in the home.

The theaters of the future must have larger projection rooms to accommodate the increasing amount of apparatus which will be necessary—manned by men who will watch over its operation with the skill and care of a conductor directing an orchestra. Such equipment may include machines for reproducing sound from a separate film record with multiple sound tracks to permit of sound perspective and special effects—with sound equipment having adequate reserve power to simulate every type of natural sounds—and with projectors capable of giving depth to the picture. Relief projection without the aid of auxiliary devices has recently been demonstrated, and these

experiments have revived the hope for the ultimate production of stereoscopic motion pictures.

Before it is possible to televise motion pictures in the theater which will be as clearly defined as the present theater picture, it is apparent that some new fundamental scientific discovery will have to be made. Utilizing present principles, the entire commercial broadcasting channel would be required to obtain sufficiently critical definition.

Color has not had a fair chance. I think that color inserts of pretty ladies are more fully appreciated, at least by the male public, than statistics would indicate. The sudden demand and the rush to obtain color prints without sufficient time for preparation made it difficult to get prints of satisfying quality. The complaint that some colored motion pictures have caused eye-strain was undoubtedly a result of the fuzziness of the pictures. The eye did not know whether the picture or itself was at fault and became all tired out trying to bring the picture in focus. This difficulty of securing colored pictures which are equally sharp as the black-and-white ones has now been practically overcome.

Much research is in progress on color work, and an ultimate solution is assured.

Investigations by the Standards Committee of the S. M. P. E. have shown that an extremely wide film is not necessary to produce a large screen picture. So far as can be predicted, a film 50 mm. wide is adequate for even the largest theaters; and, with only moderate improvements in film emulsions with respect to graininess, the present 35 mm. film would be adequate for the largest pictures possible in the average theater, especially if the picture and sound records were placed on separate films.

But these improvements will be accomplished only as a result of continued research on the part of many workers. Research work may be of two kinds—investigations in pure science or the unfolding of the secrets of nature, and industrial research, or the application of known fundamental principles to industrial practice. For example, the discovery by pure research that a hot body gives off particles of electricity and that light drives out particles of electricity from materials, was utilized by virtue of applied research to the development of vacuum tubes and photoelectric cells, which are the keystones of our modern sound recording and reproducing equipment.

To date the industry has put on the manufacturer the bulk of the burden of developing the science which it is applying, but the success-

ful producer of the future will contribute his fair share in order to insure an adequate supply of new entertaining media. But how can this be accomplished? It is not feasible for the S. M. P. E. or the Academy to establish a research laboratory, but they can help stimulate research and contribute toward the establishment of research fellowships in the various universities throughout the country. As a result of negotiations with the Massachusetts Institute of Technology and the School of Optics of the University of Rochester by our Society, I am authorized to state that these universities will, if the necessary funds are forthcoming, establish fellowships for the investigation of problems appertaining to the motion picture industry. I have in mind such problems as the effect of viewing motion pictures on eye fatigue and the merits of non-intermittent projection, which can only be conducted successfully by the collaboration of a large number of individuals. I know of no more valuable contribution which you can make for the welfare of the industry.

In conclusion, may I remind my co-workers of a tribute paid to the engineer from this platform three years ago by the late Milton Sills on the occasion of the banquet tendered our Society by the Academy. These were his words: "If I had my life to live over again, I should not elect to be an actor, but a scientific research worker. We actors get our names in electric lights, but we are soon forgotten and pass into oblivion. You scientists are making contributions of lasting value and are therefore giving one of the greatest services to the human race."

My first introduction is to one of our technical members whose researches have been largely responsible for the vacuum tube which is used in our sound recording and reproducing apparatus—Dr. Lee de Forest.

DR. DE FOREST: Chairman, guests, those who enjoy the Society of Motion Picture Engineers, and Motion Picture Engineers: it is a great pleasure to be here in Hollywood, and to greet the Convention as a resident. I am reminded as I sit here tonight of what happened 10 years ago this month, for I have here by my side the first talking motion picture cameraman and sound recorder, William Garrity. It was 10 years ago that Garrity recorded sound on picture film for the first time in America. That was in my laboratory in New York City. Microphones were not much in those days. On that occasion the small microphone used was concealed beneath Mr. Garrity's vest while he posed before the camera. The recording was what you

can well imagine it was. Mr. Garrity is now engaged in the very interesting work of recording the Disney cartoon films instead of trying to record the voice of human action. And had we contented ourselves at that time with the recording of the more or less imaginary sound of cartoons, we might have succeeded much more rapidly than we did. For those first recordings were much like those sounds which Mickey Mouse makes from the screen today. I know that we have a long program and I do not want to take up more time. I want to congratulate our President on his most enlightening discussion of the present state of this art. It was most interesting.

My position out here makes me think of the traveling salesman representing the Scottish mercantile firm, who was shipwrecked on the Hebrides Islands, and who sent a telegram to his home office asking instructions. They replied, collect, "Your summer vacation began as of yesterday." I feel, while I am out here enjoying the delights of watching what my successors are doing in this art, very much like that salesman, only shipwrecked on a South Sea Island. I am having a delightful time keeping in touch with the rapid strides, the impressive improvements which you motion picture engineers are making in Hollywood, and I am glad to know you all.

MR. FRANK WOODS: I was very much impressed by the statement made by your President of what the engineers have accomplished and some of the things that they hope to accomplish. My memory of this business goes back to the time when the engineer was unknown. The technical man was not even referred to in those terms. The technicians of those days—the earliest days of pictures—consisted of the cameraman, possibly a "prop" man, and the laboratory men. The art department was a painter who painted on canvas drops and sides. He sometimes painted an audience on the back of the canvas. In the picture *Ben Hur*, the first time it was made in 1907, the audience was painted on a back drop and when the wind blew the curtain, you really had a moving picture—the audience moved. The actor was afraid to work in motion pictures under his own name, so he would apply for the job of "posing" under a fictitious name. Some of those fictitious names became well known in pictures afterward. The director directed his pictures from what were called suggestions. There were no writers in motion pictures. If one wanted to sell an idea to a company, he would sell a suggestion. When I entered the business, the price of a suggestion was fifteen dollars. Some of the companies paid only five dollars. The author

was only known to the picture business as the person from whom we stole a story. It is a long way from that time to this—twenty-three or twenty-four years—not so long in time, but very long in things that have been accomplished. For example, the technicians have now become engineers. I think the word itself has an impressive sound to the producers. Engineers are now recognized by the producers as a class of people on whom they have to depend and to whom they cannot dictate, because as a rule they do not know what the engineer is talking about. The writer—he should really be called an author—has not yet arrived at that position, but he is improving in his standing. Through the Academy the screen authors of the present time are now preparing to negotiate an understanding by which they hope to achieve a greater freedom of authorship, all of which is meant to bring about better motion pictures. For this improved standing the screen authors must thank the engineers because it is due to the achievements of the engineers that the writers are now being better recognized and can lay claim to genuine authorship. When the engineers gave us the talking picture, it became more and more necessary that complete scripts including dialog should be written—scripts that could not be tampered with after having been composed. Hence the author owes to the motion picture engineers a great debt of gratitude.

MR. CLINTON WUNDER: President Crabtree, Mr. Chairman, friends of the Academy and of the Society: I am in a difficult spot because on one side of me is a granddaddy of the Academy, who was present at its birth and fed it from a bottle and nursed it through infancy, and on the other side of me is Mr. Crabtree who speaks a technical language about which I profess to know little. My duty remains to represent the Academy.

Twelve years ago, I made my first speech on motion pictures in New York City. At that time, there were seventeen speakers on the program. Tonight history is repeating itself for there are fifteen speakers on this program, which suggests to me that brevity is in order.

The combined technical and scientific intelligence of those who make up the ranks of the Society of Motion Picture Engineers and the Academy of Motion Picture Arts and Sciences have projected the human voice in a mighty volume which everyday rings out in twenty-seven languages into the ears of peoples of every community in the world where electricity can be had. A weekly world audience

of 250 million people (white, yellow, and black) hear what you record.

When silent pictures decided they wanted to speak, you gentlemen helped to teach them how. The speed with which they gained this vocabulary, the clearness of their pronunciation, the success of their words, they owe to you. Nor is entertainment the only product of your scientific achievements. The little red schoolhouse, the church, the university, and the great convention auditoriums now ring with the messages of education, the words of leaders of social thought, and the voice of great statesmen. The news weekly has become a news agency of vivid information and interest since sound came in. The comic cartoon has chased our gloom away to the tuneful antics of cows, goats, mice, and cats. The voice of the greatest clergyman is now heard in the smallest rural church accompanied by the choruses of trained singers which hitherto only the wealthiest congregation could listen to.

Therefore, not only Hollywood welcomes you today, but the people of two continents welcome you. They watch with interest that which you will say and do throughout your convention program. They will expect ever-continuing improvement of this vehicle you have taught them to enjoy. The Society and the Academy have much in common. Many belong to both the Society and the Academy. We benefit from the discoveries and the researches made by each other. Gains are placed together in the same treasury. Your interests and ours are the same. Your service and ours are interrelated.

The manufacturer of film, the equipment companies, the actor, writer, director, the sound engineer and technician, the cameraman, and the producers are of necessity partners. Into this partnership the public has come, by buying stocks in our companies and by placing money in the box-office. I am sure I speak for the entire Academy membership when I express the sincere hope that the acoustical properties of your convention hall's walls will be great enough to challenge anew the attention of that world audience which demands from us our best in supplying a never-ending program of films of quality to be seen, to be heard, to be enjoyed.

MR. FRED PELTON: Mr. Chairman, artists, and the Society of Motion Picture Engineers: there is a cloud over the industry at the moment. Three years ago we had not a gathering such as this, but a group of gatherings at the Biltmore Hotel, and at that time technicians of the industry contributed very greatly to reducing the

cost of making motion pictures and there was a general stimulation of technical activity. There is one problem which the S. M. P. E. can solve; and that is the problem of the silent motion picture camera. The cumbersome camera housing which we use today is a great consumer of time, and undoubtedly adds to the cost of making motion pictures. I understand that there are two manufacturer members of the Society who are producing silent movement motion picture cameras very little heavier than the old silent camera. One important thing for the Society of Motion Picture Engineers to do is to expedite the silent camera and get it into the industry as quickly as possible. This will help to dispel the cloud.

MR. CAREY WILSON: Mr Chairman, and Ladies and Gentlemen: I have been waiting for just three years—since your last convention here—to get even with you guys. Three years ago I walked innocently into something which certainly appears to have had important consequences. Mr. Woods, of the Academy of Motion Picture Arts and Sciences, asked me then if I would attend the convention of the S. M. P. E., and read a paper. So I prepared a harmless little paper and read it, and was making a graceful exit to mild applause when the chairman called me back and advised me that all speakers were required to take the rostrum and answer questions. Rather helplessly I did so. We started out with such questions as "What is a scenario?" and I answered, of course, that I didn't know. We graduated in a few minutes to such more leading questions as, "How much money does Jack Gilbert really get every week?" And a little later we got into such serious problems as the desire to know Greta Garbo's telephone number. One of the questions that turned out rather badly, I'm afraid, and that started a lot of trouble was the question, "What can the engineer do to help the writer?" That was a tough one. Rather foolishly I said off-hand:

"I think the only way is for the engineer to give the writer new machinery, so that the writer will have a broader scope and a wider field in which to exercise his talents."

Well, gentlemen, one of you guys went home to his laboratory, picked up some pieces of wire, an old telephone transmitter, and went to work. Three weeks later we had talking pictures. Six months later half the people in Hollywood were out of work, and the other half didn't know anything about talking pictures, either.

I will never ask for any more help from the engineers.

I might say to all of you, and particularly to Doctor Mees, to please

have a heart and don't go inventing anything new for a little while, until we get caught up.

You gentlemen have certainly improved matters marvelously since the introduction of sound pictures. When talking pictures first came in, I monkeyed with the idea in a rather obscure studio. The first time I went on a sound stage, I discovered the problems were many: we had a microphone somewhat resembling a sewing-machine suspended from the ceiling; you had to group your actors around that microphone until they looked like a Notre Dame huddle; but the poor cameraman was in a worse spot. The sound stage of the early days resembled the home factory of that famous character created by Chic Sale.

Then, when I went to see the picture, it happened to be running in a small house. Gentlemen, that house reminded me of the City Hall Auditorium in the small town where I once put on a high-school show. I asked the man who ran the auditorium:

"How are the acoustics?"

He said, "We ain't got no acoustics."

In the early days of sound pictures you sat and listened to your picture and wondered who it was that had translated your dialog into Chinese.

I don't suppose any of you folks realize the chaos that resulted in our industry here with the introduction of talking pictures. I can tell you a story about a director who was a practical joker, which may illustrate our confusion and ignorance of sound. This director, Micky Neilan, asked an actor friend to make a sound test. The actor, who happened to have a very deep voice, came on the set and spoke certain lines in the test. When he left, Micky got his young girl secretary to speak those same lines on a separate sound track. When the actor came back several days later to hear his test, Micky ran the actor's photograph film synchronized with the secretary's sound track. When the lights flashed up in the projection room, the actor said:

"My God, Micky, I was afraid I wouldn't record well, but I didn't think I'd turn out to be a damned soprano."

I am sure, gentlemen, improvements will have to go on from this day as they have from the pioneer days of sound. To show my respect for your abilities, I can only say that I hope we here will progress as well as I know you engineers will.

CHAIRMAN: We have with us a guest who came all the way from

Germany, and who is a member of our Society and of the Deutsche Kinotechnische Gesellschaft. Perhaps he may have a few words to say to us.

MR. HANS BÖHM: I would like to express my appreciation at being able to attend this wonderful meeting of the Society in Hollywood. All my German fellow friends of the Deutsche Kinotechnische Gesellschaft, which is very much honored to have your President as its honorary member, envied me as I left for my visit to America; and I feel sure that they will envy me even more when I return and tell them of all that I have seen and heard over here in this marvelous country of progress, research, and science.

COMMITTEE ACTIVITIES

REPORT OF THE STANDARDS AND NOMENCLATURE COMMITTEE*

WIDE FILM

The last report on the work of this committee was presented to the Society at the New York meeting in October and appeared in the December, 1930, issue of the JOURNAL. The present report is concerned chiefly with the activities of a subcommittee consisting of Messrs. Batsel, *Chairman*, Evans, Griffin, La Porte, Shea, Spence, and Sponable, which was appointed to study the wide-film situation. The recommendations of this subcommittee (wide film) have been considered and approved by a majority of the Standards Committee, either at the meeting held in New York on May 2nd or by correspondence.

The problem of a satisfactory wide-film layout has been under consideration by this committee for some time, and previous reports have discussed its many obvious advantages and its economic limitations, due in part to the existence of a large amount of 35 mm. equipment. This committee has felt that the adoption of release prints having a width of 65 or 70 mm. is economically impractical and has, therefore, been working for some time on an intermediate film size that would have most of the advantages of the wider film but that could be used interchangeably with 35 mm. film in existing projectors after suitable alterations. As indicated in our last report, the ratio of picture width to height is constrained by the balcony cut-off and proscenium arch in existing theaters to be in the neighborhood of 1.8 to 1. The combination of a picture of these proportions, the feature of interchangeability with 35 mm. films, and provision for a sound-track of adequate width with suitable margins leads to a film approximately 50 mm. wide.

A tentative layout for a 50 mm. release print had been drawn up at

*Presented at the Spring, 1931, Meeting at Hollywood, Calif.

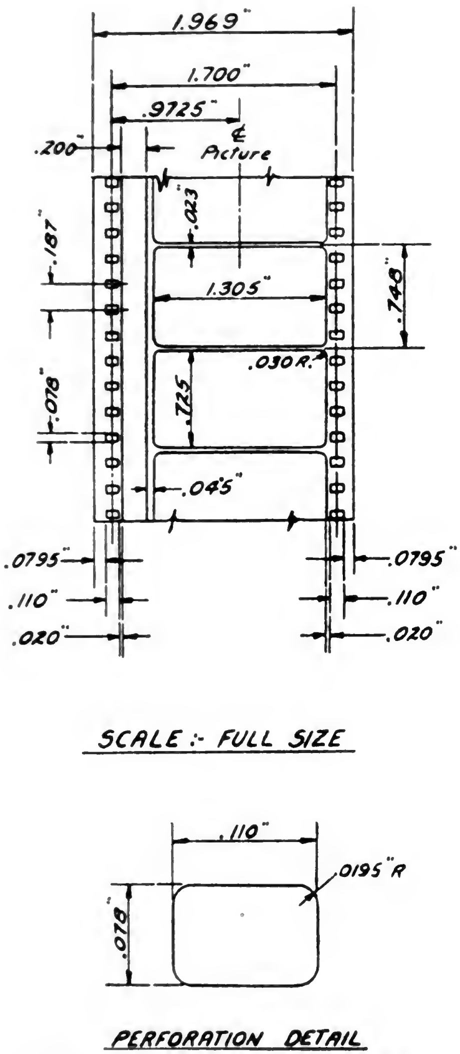

Fig. 1. Layout for 50 mm. unshrunk release print.

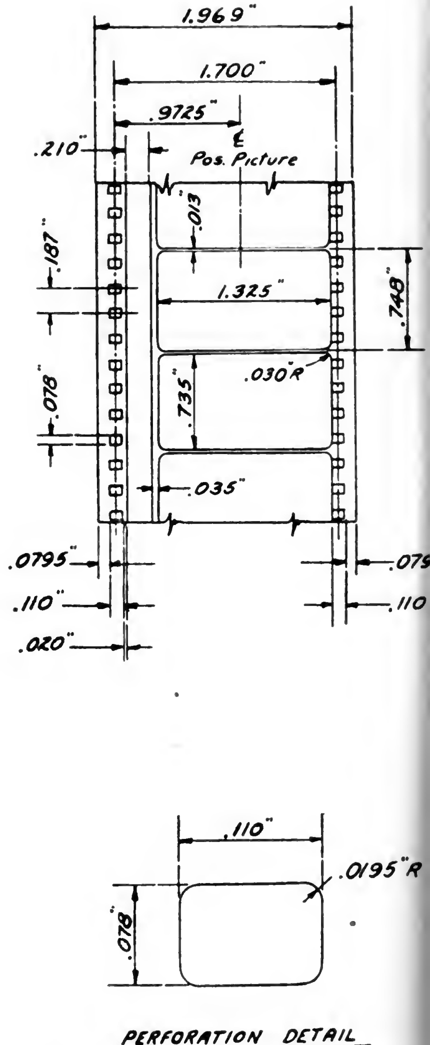

Fig. 2. Layout for 50 mm. unshrunk negative.

the time our last report was presented but it was not included with the report because the committee had had no opportunity of putting it to a practical test. Through the unstinted coöperation of Mr. Sponable and others, equipment for taking, processing, and projecting this film has since been made available to the subcommittee so that actual tests of the suitability of the new film could be made. It is the unanimous opinion of this committee that the new film has all the important advantages of the 65 or 70 mm. film, and that, due to its narrower width, all the major difficulties involved in handling the wider films have been eliminated. We are including in this report the layout drawn up by the subcommittee for a 50 mm. (unshrunk) release print (Fig. 1) and a 50 mm. (unshrunk) negative (Fig. 2.).

We wish to make it clear that, due to the present lack of interest in wide film on the part of the producers, we are not asking the Society for formal approval of the 50 mm. film dimensions at the present time. We are, however, publishing this report as a matter of record, so that when and if the industry desires to make use of the superior results achieved with the wider film, the results of this work will be available. It is contemplated that, if sufficient interest becomes apparent, a demonstration of the new film before the Society can be arranged at some subsequent meeting.

GLOSSARY

A subcommittee on nomenclature under the chairmanship of Mr. Rayton has prepared a careful revision of the glossary of motion picture terms that appeared in No. 37 of the *Transactions* of the Society. A large amount of work has been done on this project to bring the definitions into line whenever possible with those already adopted by other societies such as the Institute of Radio Engineers, the American Institute of Electrical Engineers, the Optical Society of America, the Illuminating Engineering Society, and the Academy of Motion Picture Arts and Sciences. Mr. Rayton's subcommittee has been very ably assisted in this work by Messrs. R. E. Farnham, Clifton Tuttle, T. E. Shea, and Sylvan Harris (editor-manager). The glossary will appear in an early issue of the JOURNAL.

STANDARD PRACTICE

The subcommittee on standard practice under the chairmanship of Mr. Rackett has carried forward the program previously outlined

(*J. Soc. Mot. Pict. Eng.*, **XV** (Dec., 1930), p. 818.) but has no formal report to make at this time.

A. C. HARDY, *Chairman*

J. O. AALBERG	L. A. JONES
M. C. BATSEL	N. M. LA PORTE
W. H. CARSON	G. A. MITCHELL
L. E. CLARK	G. F. RACKETT
J. A. DUBRAY	W. B. RAYTON
P. H. EVANS	C. N. REIFSTECK
R. E. FARNHAM	V. B. SEASE
L. DE FOREST	T. E. SHEA
H. GRIFFIN	J. L. SPENCE
R. C. HUBBARD	E. I. SPONABLE

L. T. TROLAND

DISCUSSION

MR. DUBRAY: To all appearances, the size and shape of the perforations as recommended offer dimensions suitable for 50 mm. film which would prove adequate, especially considering that the rectangular perforation is recommended for both negative and positive.

I have been in Hollywood for the last six months and have conducted a personal investigation from which it appears that the ratio 1 to 1.8 for the motion picture image is not in accordance with the apparent needs of the artistic workers in the motion picture field. Cameramen, directors, art directors, *etc.*, object quite strenuously to such an elongated form of the screen, contending that it is not adequate for the proper pictorial presentation of the great majority of motion picture scenes.

The Committee has been, in my estimation, considering a maximum width necessary to fill the proscenium, and has suggested a height suitable to the geometry of the auditorium. However, I do not believe that it is essential to cover the entire width of the proscenium, and it appears that a ratio of approximately 3 to 5 better answers the requirements of the artistic workers of our industry.

I would like to suggest that very close collaboration with the American Society of Cinematographers and the Academy of Motion Picture Arts and Sciences would be highly desirable in order to arrive at a better understanding than we have today.

MR. BATSEL: In deciding upon the 1.8 to 1 ratio, consideration was given not only to the dimensions of the theater stage openings, but also to the ratio which would permit the picture to be viewed without allowing the edges of the picture to intrude upon the viewer's consciousness. Everyone will agree that with the present dimensions of the picture, one is always more conscious of the sides than of the top and bottom. When viewing the 2 to 1 picture, one is conscious of looking through a window which is too wide. These pictures were

viewed under various conditions, and appear to be very easy to look at without being overly conscious of the sides or top, although the ratio is not the whirling square ratio which the artist likes. I think that it most fully meets the requirements of the theaters and at the same time gives one a wider angle of view than the 1.6 to 1 ratio. The dimensions of the perforations were debated for many hours. I cannot begin to repeat the arguments that were given for wider perforations or for the standard perforations. But after many meetings, everybody who attended was convinced that the recommended perforation would be satisfactory. Mr. La Porte has done considerable work with this film. Mr. Sponable has had experience with 70 mm. film and has tested the 50 mm. film with standard perforations. Others have run many 63 and 65 mm. film with the same perforations, and all the data we could accumulate indicated that it would be perfectly satisfactory.

MR. GRIFFIN: For the sake of argument, we might all agree with the artists in so far as their opinions on the size of the picture are concerned. However, the artists and the directors are not dealing with the theater. They are dealing with the artistry of the picture, and are doing a good job. However, a very comprehensive survey was made which definitely indicated that pictures of dimensions other than those which have been submitted would in the majority of cases be impracticable. The proscenium arch and the balcony height, and all the things to be considered when changing the size of the picture, must be very carefully considered before standardizing on a definite size of picture.

PRESIDENT CRABTREE: Should we not establish what is the best proportion and in the future design theaters accordingly?

MR. GRIFFIN: That would be an ideal procedure, but there are already 22,000 theaters in the country into which we may have to put the new picture, and it would not be well to standardize on any size that would not be suitable for all these houses.

MR. SCHLANGER: The proscenium arches are made of metal lath and can be altered to accommodate the right size picture, and the balcony seating arrangement can be changed as well.

MR. GRIFFIN: That may be true in many instances, but consider this proscenium. It would be a difficult matter to move it without going to the outside of the building; and such a condition exists in the majority of theaters not constructed along the lines of the *de luxe* houses. It is not a matter of height, but of width, and if we extend the picture to the side walls of the theater it would be a rather poor thing to look at. It must be framed according to the size of the theater in which it is being presented.

MR. DUBRAY: I agree with some of Mr. Griffin's statements, but I am afraid that my statements have been misunderstood. I do not intend to suggest that a screen having a 3 to 5 ratio should fill the total width of the proscenium. This would, of course, not permit people sitting at the rear of the auditorium to see the entire height of the picture.

What I intended to say was that a maximum possible height should be determined, letting the width of the screen take care of itself in the proportion of 3 for the height to 5 for the width.

MR. GRIFFIN: While the 3 to 5 ratio may be artistically good, it is still open to the objections I have already stated. But there is another consideration—

we are talking in terms of wide film; and I have seen pictures of various ratios projected, including that suggested by Mr. Dubray, and those approximating that ratio seem only to be glorified 35 mm. pictures. They do not give the effect which we all seem to be after—the so-called wide picture. Mr. Dubray has not seen actual samples of film made by the Committee for our use. They are really beautiful, and as Mr. Batsel said, are very easy to look at.

MR. SCHLANGER: As far as the structure of the building is concerned, I agree that one must sacrifice width for size of structure. However, there may be simultaneous actions occurring on both sides of the picture, and if the film is too wide it may be difficult to connect both actions with the proper vertical accent which affects good picture positions.

PRESIDENT CRABTREE: Mr. Hardy emphasized the importance of the interchangeability of the mechanism for use with 35 mm. film. What saving would that involve—that is, what is the difference in price between such a combination machine and a new machine to handle the 50 mm. exclusively? One would assume, of course, that the 35 mm. film would be retained until the industry is ready to switch to the 50 mm. type.

MR. GRIFFIN: In order to introduce wide film at all it would have to be introduced in a very economical way. Two sets of equipment cannot be installed in any projection room; certainly not in 90 per cent of the theaters. That means that it would be impossible to introduce wide film to any large extent with the existing 35 mm. equipment installed. The problem, then, is to make equipment that can be changed within a few seconds so that either 35 mm. or 50 mm. film can be run on the same equipment. The cost of building 50 mm. equipment would not be much greater than the cost of building the present equipment, but it would not have the interchangeable feature. It so happens that 50 mm. film can be readily installed in any of the theaters with the existing type of equipment at a very nominal cost. I cannot give the price because that data is not available.

PRESIDENT CRABTREE: Could you outline exactly what has to be done to change over the machine?

MR. GRIFFIN: The same intermittent movement, the same shafts, and the same gear ratios are used as in the 35 mm. equipment, but the sprocket structure is simply lengthened out so that one end of the sprocket may be pushed in for 35 mm. film and pulled out for 50 mm. film. The second change is to pull out the 35 mm. aperture and substitute a 50 mm. aperture and guide for the 50 mm. film. The only other change necessary is to replace the gate which can be done in a few seconds. The same procedure applies to any sound equipment, and the magazines must be widened by using a new door. These features are very inexpensive as compared with the cost of new equipment specially built for one size of film.

PRESIDENT CRABTREE: Will such sprockets get out of alignment and perhaps damage the film?

MR. GRIFFIN: Not with the construction under consideration. The feed sprocket and hold-back sprocket are easily changed, and only a relative amount of accuracy is required; but greater accuracy is necessary in the case of the intermittent sprocket. The problem is far from being insurmountable.

PRESIDENT CRABTREE: I would like to suggest to the Chairman of the Com-

mittee that in order to enable the members who did not have the opportunity to attend this meeting and to hear all these intimate discussions to vote intelligently, the report might be somewhat elaborated, including a few of these reasons why the Committee has arrived at this decision.

MR. JONES: It seems to me that the Committee has proposed a very definite disposal of this report. As Mr. Hardy points out, the Committee is not proposing a standard to be adopted by the Society at present, but has presented the conclusions it has reached up to the present time. If I understand correctly, the Committee proposes to let the matter rest in this state until such time as it seems expedient for the Society to take a definite action and I think Mr. Hardy, after this discussion, will present further facts for the adoption of this matter. Our course is to accept the report of the Committee and to do with the report just what the Committee asks us to do. This is a tentative recommendation.

MR. SHEA: It is greatly to be hoped that at the next convention Mr. Sponable will be able to give a demonstration with his apparatus such as he gave to the members of the Standards Committee, and it is also to be hoped that Mr. Griffin will describe his projector. Until this shall have been done, discussion of details seems ineffective.

MR. GRIFFIN: The equipment will be available at the next convention if it is desired. The wide film program was started by one manufacturer and did not meet with the approval of other producers. We do not want to force the matter of standardization but we do want the producers to study the matter carefully and come to their own conclusions.

REPORT OF PROJECTION SCREENS COMMITTEE

The Projection Screens Committee commenced its operations in March. The first meeting was held on April 16th in New York, N. Y., at which the Chairman submitted a preliminary outline of the work proposed for the Committee to undertake. This outline was discussed and elaborated and as a result a second and more detailed outline was prepared and distributed among the members. The second meeting was held on May 14th. This preliminary report is based largely on material submitted and examined at that time.

The main lines of endeavor are outlined as follows: Manufacture of Screens, Mechanics, Light Reflection Properties, Sound Transmission, Illumination, and Rear Projection Screens. Responsibility for the different sections has been assumed by the members with regard to their familiarity with the different fields. Considerable data will be collected on light reflection properties, brightness values of screens in theaters, and manufacture, installation, and maintenance of screens. It is also hoped that the Committee will be able to make recommendations as to the type of screen to employ under specified conditions of use.

The following is in the nature of a preliminary report and, therefore, is not as complete and conclusive as we should like it to be. Nevertheless, it is our opinion that it offers material which the Society may find of interest at the present time and will indicate what may be looked for in our later report.

MANUFACTURE OF SCREENS

Bases.—The manufacture of sound screens is a critical undertaking in which all details must be given due consideration in order that uniformity and high quality of finished product may result. Most screens employ a fabric as a base although there are some which employ a metal. Essentially, the purpose of the fabric is to provide the necessary strength for the screen and to serve as a carrier for the light reflecting surface. Quite often the fabric is coated with a cellulose compound and the combination employed as a base. With some screens a slight translucency of the fiber from which the fabric is woven is desired. This is the case when the rear surface of the screen is colored in an attempt to impart to the reflected light a slight tone of the particular color used. It is more customary, however, to make the fabric as nearly white and opaque as possible in order to improve its light reflecting qualities.

Surface Treatment.—The base fabrics are treated in various ways to give various reflection characteristics to the screens. The surfaces are classified as matte or diffusing, beaded, or metallic, the latter two being somewhat directional in their distribution of illumination. They may be applied by a knife spreader process, by printing with rollers, or by spraying or painting. Great care must be taken to secure a uniform and sufficient thickness of coating to provide good light reflection characteristics while staying within the limits imposed by other conditions. As yet, no detailed information has been collected in regard to the materials which are commonly used for surfacing.

It is present practice to color the backs of screens for purposes of identification. As mentioned before, however, color is sometimes used with thin surface layers to provide a slightly selective reflection characteristic.

Materials for coating vary greatly in their properties. Some diffusing screens are slightly glossy and others have perfectly flat white surfaces. Flat white seems best for avoiding surface glare and undesirable reflection at the seams. Diffusing surfaces may be hard

or soft, smooth or rough. A hard smooth surface without sheen is apparently desirable since it is less apt to collect dirt and is easier to clean. Beaded screens require ingredients to hold the beads firmly in place. Most surfaces are formed from pigments and gums, oils, or other binders. In general, the gums and oils cause screens to become yellow with age.

Fireproofing.—At various times there has been agitation in regard to fireproofing of screens. This situation grew out of the practice of using highly inflammable nitrocellulose bases. Screens of this type are undoubtedly fire hazards and their use has been largely discontinued. At present, practically all screens are either slow-burning or fire-resistant. They are made so by properly selecting the materials and by flame-proofing the base fabric prior to treatment of the surface. This Committee has found that it is impossible to successfully fireproof a screen after manufacture or when in place in the theater. It must be remembered that the screen is a small item in the stage equipment of a theater, that it is usually much less inflammable than the surrounding draperies, and that usually it is hung vertically and stretched tight, so that it is not likely to be the cause of fire. We know of no case in which slow-burning or fire-resistant screens have caused fires. In general, it devolves upon the exhibitor to make his choice of screens, depending on his own local ordinances and conditions. The Committee is considering a recommendation relative to the marking of all screens which have been flame-proofed so that difficulties arising in this connection may be eliminated.

Sound Requirements.—After many tests, the necessary requirements as to the ratio of open to solid space in sound screens have been determined by producers of sound equipment, and screen manufacturers have guided themselves accordingly. Screens of the perforated type in present use have a ratio of open to solid space of approximately 8 per cent; screens of the porous type have a rather larger ratio. Acoustic theory indicates a minimum of 5 per cent as desirable. Perforations generally are made after the screen is surfaced.

Seams.—In assembling screens the seams should be placed vertically. Care must be taken not to stretch the screens too tightly. Butt joints are used with some metallic and beaded screens employing cellulose coated fabric as the base but are not generally used with others.

MECHANICS

Size.—The distance between the front row of seats and the screen is one determining factor for the size. The larger the picture, the more plainly imperfections in the film, such as graininess, show up. This is very noticeable and objectionable in the nearer seats. Also, since the eye can satisfactorily accommodate itself to movement throughout a 60-degree angle, the distance between the front row and the screen should approximate 0.87 foot for each foot of screen width. For a 15-foot picture, a distance of at least 13 feet should therefore be provided.

The size of picture should be determined by its distance from the rear seats. The width of the screen should be equal to approximately one-sixth the distance from the screen to the rear seats. For a distance of 120 feet, therefore, a 20-foot picture should be used, provided there are no seats nearer the screen than 17 feet and the projection angle is not very great. These rules are intended only as guides.

The standardization of sizes is of primary importance to both manufacturer and exhibitor. Many errors are made in ordering screens because of confusion in description, resulting in considerable monetary loss. Sizes have already been standardized by several manufacturers and large users, but not always in the same way. The Committee is considering for recommendation a set of dimensions to be used as standards and sub-standards.

Mounting.—Each manufacturer should determine the best method for mounting his own screens and advise purchasers accordingly. By taking proper care in mounting the screens, damage and cost of installation can be reduced considerably. A survey of instructions sent by manufacturers may lead to general rules. These may be drawn up into a revised instruction sheet for consideration by manufacturers.

Masking.—The usual masking is black. This results in a very marked frame which reduces the effect of "jumping" of the picture caused by the film or projecting equipment. It has been felt that the resulting contrast is too great and various persons have advocated an intermediate gray. We are considering a suggestion that the mask be graded from black to lighter grays with the black edge next to the picture.

Deterioration.—All screens deteriorate with age: "silver" screens tarnish, other types become yellow. Yellowing of the surface is

accompanied by a reduction in reflection value and by an undesirable color tone which is imparted to the picture. Yellowing is usually caused by gums and binders and not by the pigments. We are informed that of late there has been marked improvement in this respect.

In addition to discoloring screen, accumulated dirt also causes a deterioration of reflecting qualities. The amount of dirt collected depends on the condition of the air in the theater, the precautions used to protect the screen, and the nature of its surface. It is essential that draperies surrounding the screen be cleaned regularly and that circulation of air through the openings of the screen be prevented. If possible, it should be enclosed when not in service, even though with the cheapest kind of material. The average useful life of a sound screen varies from one to two years, depending on the conditions of use.

Cleaning.—Even with these safeguards the screen will gather dirt. An examination will indicate whether the dirt is dry or oily and, therefore, whether the screen may be brushed or not. If brushing is permissible, a long handled special brush should be obtained and the screen brushed once a week. It is also helpful to use a vacuum cleaner on the rear surface. More thorough cleaning should be done by experts who have sufficient scientific knowledge of screen materials to devise safe and suitable methods. Furthermore, certain types of screen cannot be cleaned satisfactorily at all. Each manufacturer should advise the users of his screens as to the possibilities.

Reprocessing.—Renewing of the surface of diffusing screens by spraying is receiving considerable attention. When carefully done and when the proper materials are used, completely satisfactory results seem to be attainable. The spraying pigment should be highly reflecting, should not fill up perforations, and should not become yellow with age. The screen and surroundings should be thoroughly cleaned before the processing is undertaken. Such a renewal of the surface is not feasible on all types of screens.

LIGHT REFLECTION

Total Reflection Factor.—There are several ways of defining the total reflection factor, based on the methods of test used in different laboratories. The laboratory which makes most of the commercial measurements of screen reflection characteristics employs a method in which the light is incident on the test sample from all directions within a cone of 180 degrees. The angle of observation is 12 de-

grees from the normal, and the light returned in this direction is taken to indicate the total reflection factor. The Committee advocates the adoption of this definition as standard.

Angular Distribution.—One of the most important attributes of a screen is its ability to reflect the incident light to the observers. Angular distribution curves in the past have been obtained with light at normal incidence. Data collected by this Committee show that the average projection angle is approximately 15 degrees, measured to the perpendicular to the screen. Therefore, we believe that measurements with light incident on the test sample 15 degrees above the normal will give information more in keeping with conditions of actual practice. The reflected light would be measured in

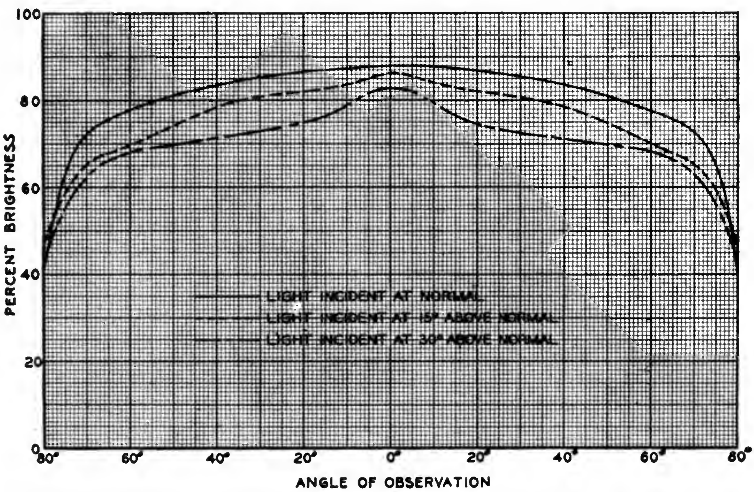

FIG. 1. Distribution of brightness in horizontal plane for diffusing screen.

a horizontal plane and in a vertical plane containing the light beam, both normal to the screen sample. A more complete discussion of this question will appear in our later report.

The accompanying curves, Figs. 1–6, illustrate the variation in distribution of light at three angles of incidence, 0, 15, and 30 degrees from the normal. It will be noted that with a smooth diffusing type of screen the difference beween measurements at zero and the other angles is appreciable but that the distribution is relatively uniform. In the horizontal plane, there is considerable diminution of reflected light and some equalization in distribution

for both beaded and metallic types. In the vertical plane for a beaded screen it is a distinguishing feature that the axis moves to follow the incident light beam so that a good portion of the light is reflected back upon itself. With a metallic screen, the axis is at the specular angle. It is planned to make recommendations for the types of screen to be employed in theaters of different architectural design, as is now being done to some extent, but as yet the Committee is not ready to go on record with definite suggestions.

Variation across Screens.—Because of non-uniform light incidence over the total area of the screen and because of the non-uniform reflection characteristic, there will usually be variations of bright-

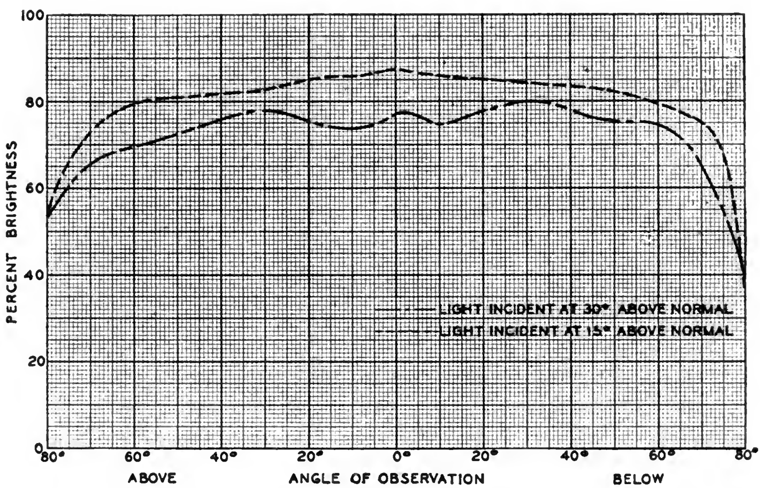

FIG. 2. Distribution of brightness in vertical plane for diffusing screen.

ness in a projected picture. All theaters are subject to this effect at the front of the house but, of course, the continuous change of intensity in the pictures reduces its noticeability. We shall propose limits for allowable brightness differences.

SOUND TRANSMISSION

Theory.—The design of screens from the standpoint of sound transmission presents problems which are simple in comparison with optical considerations. The great importance of good sound transmission characteristics should, however, be recognized. An analysis of the general problem of transmitting sound through a material such as a screen indicates several possible methods; certain practical

considerations, however, limit the designer to the use of two. A screen may be expected to radiate sound as a result of being set into vibration by sound impulses emanating from the loud speaker immediately behind it, or the sound impulses may be transmitted through the air spaces in the screen material. These air spaces may simply be those due to the porosity of the material itself, but better control of the transmission characteristic may be effected by deliberately providing air passages of the proper size and number. This may be accomplished by careful weaving, punching, or other means. All commercial types of screen depend largely upon this method of transmission although many depend upon the diaphragm

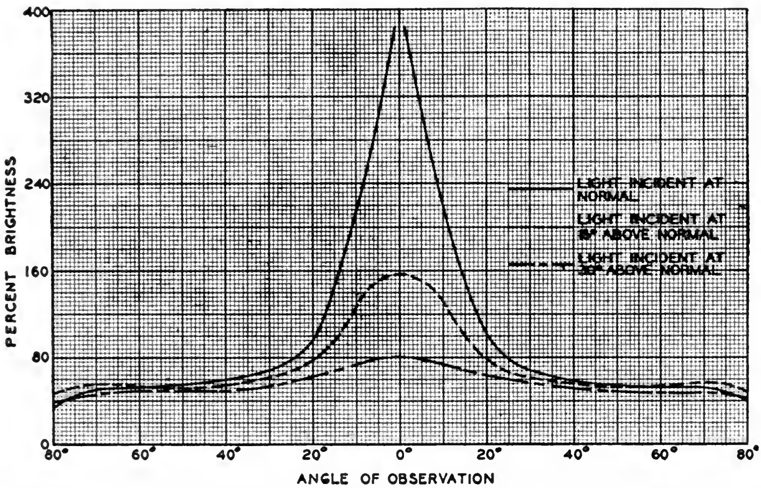

FIG. 3. Distribution of brightness in horizontal plane for beaded screen.

action of the screen to overcome a loss which may occur at low frequencies due to a decrease in the radiation resistance of the air passages in this part of the frequency range.

Because of the desirability of affecting the optical characteristics of the screen to as small an extent as possible, the perforations or air spaces in the screen are made as small as is practicable and their number is limited to the absolute minimum. Fortunately, it is possible to obtain quite satisfactory sound transmission by using rather small, widely spaced openings which, in the aggregate, offer a comparatively small total open area in the screen. It is felt that an aggregate open area amounting to 5 per cent of the total screen

area may be considered tolerable from the light reflection standpoint. On this basis it is found that the sound requirements may be met without impairing the detail of the picture. The relations between the screen thickness and the size and number of the holes may be worked out rather easily by applying the known acoustical theory; an approximation will serve, however, for the practical designer. For perforated screens it has been found, in general, that if the diameter of the perforations is equal to three or four times the thickness, the aggregate area of the openings being 5 per cent of the total screen area, satisfactory results may be obtained. This applies to the usually used materials and, of course, must at present be considered true only for them. Furthermore, it applies only over a

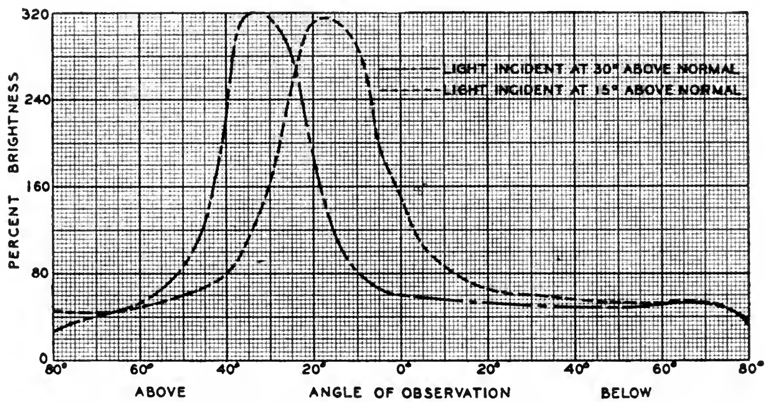

FIG. 4. Distribution of brightness in vertical plane for beaded screen.

limited range of screen thickness. This relation shows that it is desirable to keep the screen thickness at as low a value as is mechanically and optically practical.

Test.—It is the present practice to measure the sound transmission characteristics or response characteristics of each type of screen before approving it for use with sound projecting equipment. Although there are various methods by which these acoustical measurements may be made, the commonly used method involves response-frequency measurements of the output of a loud speaker with the screen placed before the speaker in its normal position and with the screen removed. In order to adhere as closely as possible to actual field conditions in making these measurements, a loud speaker of the type used in the field should be employed. Since

this method of test approximates closely the theater conditions and since it includes the effect of the diaphragm action of the screen, if present, it is probably the most desirable method of making the measurements. The response measuring technic should conform with accepted loud speaker response measuring methods.

Tolerances.—There are three factors which must be determined before a proper judgment of screen performance may be made. The general loudness attenuation effect, the frequency range for sound transmission, and the regularity of frequency response all enter into the determination of the suitability of a screen from the acoustical standpoint. In general, little trouble is experienced in obtaining efficient low frequency response. Usually, however,

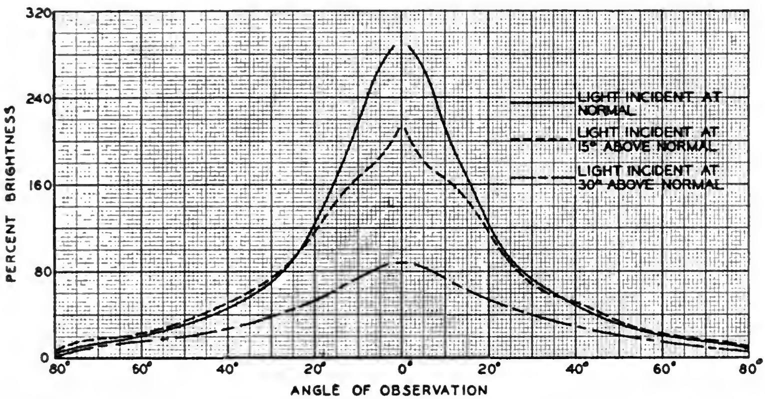

FIG. 5. Distribution of brightness in horizontal plane for metallic screen.

screens exhibit a drooping characteristic at high frequencies. Since the droop at high frequencies is usually rather gradual, no definite frequency range may be assigned to the screen response; the allowable loss at certain high frequency points relative to the 1,000-cycle response should be specified. On the whole, it must be observed that it is difficult to set absolute limits for screen response, covering all possibilities. The following have been applied successfully to the great majority of cases by the two largest manufacturers of sound equipment:

A loss of 2.5 db., as given by the average response curve, at 6,000 cycles, relative to the 1,000-cycle response, is considered a desirable limiting value for existing types of sound equipment. Screens that meet this requirement are usually found to

attenuate less than 4 db. at 10,000 cycles. As to regularity of response, variations greater than ±2 db. would not be tolerable. Because of standing wave effects in the measuring room, inaccuracies of measurement may occur, causing variations somewhat greater than this below 300 cycles. It is felt that no limits for regularity should apply below this frequency. The interpretation of measurements must be left to the discretion of one closely acquainted with the measuring conditions. A general attenuation in loudness, as judged from the measured screen transmission characteristic, greater than 1 db., is not considered tolerable. Although this limit may appear rather stringent, there are many screens available which meet

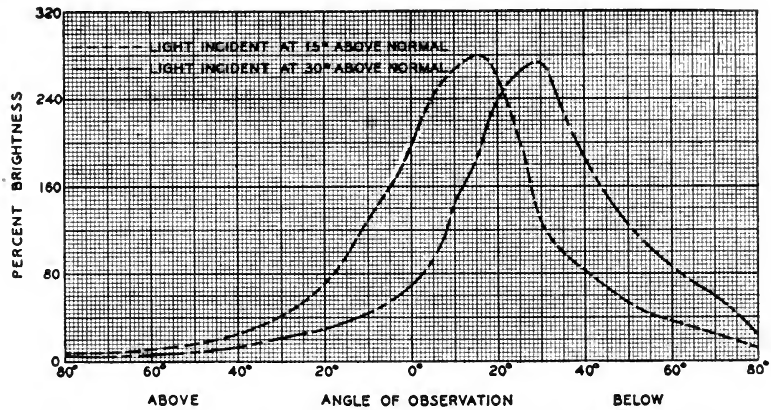

FIG. 6. Distribution of brightness in vertical plane for metallic screen.

this requirement. It seems advisable to maintain this high standard for sound transmission.

ILLUMINATION

The study of screen illumination is one of the primary aims of this Committee. We hope to determine average values of brightness encountered in theaters and to discuss these in relation to stray light, print density, and physiological factors. Also, we plan to consider and standardize methods of measuring brightness, which, at the present time, because of their lack of uniformity, render the comparison of data difficult. Some information on screen brightness has been accumulated but not sufficient for presentation at this time.

REAR PROJECTION

Rear projection is attracting wide attention at the present time in New York and promises to develop into a field of interest throughout the country. The manufacturers of this type of screen are not as yet willing to release engineering information so that we are postponing discussion of this for our later report.

S. K. WOLF, *Chairman*

D. S. DE AMICIS	W. F. LITTLE
F. M. FALGE	A. L. RAVEN
H. GRIFFIN	C. TUTTLE

D. F. WHITING

THE HISTORICAL COMMITTEE

On account of the wide geographical distribution of the members of the Historical Committee it has not been possible to accomplish as much as was desired, but largely through the efforts of one of its members, Mr. W. Theisen, an exhibit of historical films and apparatus was arranged for the Hollywood Convention. It is the hope of the Committee that this exhibit has aroused the generosity of the members and others who have objects of historical value to the end that these objects may be placed in the hands of the Committee to be housed in fitting museum repositories where they will be available for public inspection, and accessible particularly to the interested members of the Society of Motion Picture Engineers.

Much historical data and records have been collected by the Committee and are being classified in loose-leaf binders for final museum deposition. Under this classification records are being filed, mainly according to outstanding personalities in the early days of the industry. Among these personalities are included: Georges Demeny, Wm. Kennedy Laurie Dickson, Thos. A. Edison, Wm. Friese-Green, C. Francis Jenkins, Eugene Lauste, Louis Aimé Augustin Le Prince, Auguste and Louis Lumière, Jean A. LeRoy, Ettienne-Jules Marey, Eadward Muybridge, and others.

The Historical Committee wishes to express its gratitude for the kindly and generous coöperation and contributions to its work of such men as E. Kilburn Scott, London; Will Day, London; Jean A. LeRoy, New York; Wm. Kennedy Laurie Dickson, Channel Islands; J. Tarbotton Armstrong, Museum of the University of California;

J. Waldemar Kaempffert, Museum of Science & Industry, Chicago; F. C. Brown, Museum of Peaceful Arts, New York; D. D. Jackson, Chemical Museum, Columbia University; A. J. Olmstead, Smithsonian Institute; Dr. Bryan, Los Angeles Museum.

The Chairman of the Committee also wishes to express his thanks to the members of the Committee for their able assistance, particularly to the unflagging zeal of President Crabtree, C. Francis Jenkins, Glenn E. Matthews, Merritt Crawford, Terry Ramsaye, and W. E. Theisen, who have contributed greatly to the work of the Committee.

A large amount of historical data has been published, both in the technical and the popular magazines, and much of the material published has been directly or indirectly the result of the work of the Committee.

The following bibliography for the year past merits consideration:

"Evolution of Sound Pictures," by M. Crawford, *Intern. Photo Bull.*, Mar., 1930.

"Romance of Photography," *Amateur Films*, Feb., 1930.

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"Geo. Eastman," by C. W. Ackerman: *Houghton Mifflin Co.*, 1930, 495 pp.

"Beginning of Amateur Educational Films in the U. S.," by L. M. Bailey, *Intern. Rev. Ed. Cinemat.*, March, 1930.

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"From Flickers to Movies to Talkies," by O. F. Spahr, *Ex. Herald-World*, June 7, 1930.

"Role of Dyes in the Progress of Photography," by A. Seyewetz, *Photo Revue*, Dec. 1, 1930.

"Scientific Cinematography and the Work of Dr. Jean Comandon," by C. M. Croissac, *Intern. Rev. Ed. Cinemat.*, Sept., 1930.

"When the Movies First Tried to Talk," by H. S. Hulfish, *Ex. Herald-World*, Aug. 30, 1930.

"Through a Yellow Glass," *O. Blakeston*, Pool, London, 1930, 138 pp.

"Film Technique," by V. I. Pudovkin, *V. Gollanz, Ltd.*, London, 204 pp.

"Meaningless Jubilee," by G. Seeber and K. Walter, *Filmtechnik*, Nov. 15, 1930.

"The Projector Has a Birthday," by Chas. Hastings, *Mot. Pict. News*, Feb., 1931.

"William Friese-Green, England's Great Cinematographer," by M. Crawford, *Cinema*, Sept., 1930.

"A Mystery of the Motion Picture's Beginnings," by M. Crawford, *Cinema*, Dec., 1930.

"First Days of the Movies," *Literary Digest*, Jan. 10, 1931.

"Los Padres del Cine," by M. Crawford, *Cine-Mundial*, Feb., 1931.

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DEMONSTRATION OF EARLY MOTION PICTURES AND HISTORICAL TELEGRAPHONE AT THE HOLLYWOOD CONVENTION*

During the Spring, 1931, Meeting at Hollywood, Calif., motion pictures, taken thirty-four years ago by Mr. Oscar B. Depue, of Chicago, were projected. In addition to these, a sound picture was projected which showed Mr. Depue addressing the meeting, and in which were included views of the telegraphone illustrated below.

The words by Mr. Depue, addressed to the Society from the screen, were as follows:

"You have just seen motion pictures that I made thirty-four years ago. They are reduction prints made from 60-mm. negative. The very first one that I made was in front of St. Peters in Rome, the grandest of all cathedrals; with the Vatican, the fountains, and the goats in the background; then the gondolas, in Venice, in front of the Piazzetta on the Grand Canal; later, the Plaza in front of the beautiful Milan Cathedral, and the Place de la Concord at the entrance of the Champs-Elysees. These were made over a third of a century ago. Now I want to take you back a quarter of a century and give you a few examples of early sound recording.

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* A contribution to the Historical Committee Report. Presented at the Spring, 1931, Meeting at Hollywood, Calif.

"It was while touring Europe with Burton Holmes in 1907 that I first learned about the Poulsen telegraphone, a marvelous little instrument that recorded sound magnetically on a fine wire. I was fascinated with the thought of recording the voice electrically; whereupon I went to Copenhagen and purchased this early model telegraphone. It is machine number 41.

"On the steamer coming home I had it set up in my cabin, and passengers hearing about it used to make short records and were delighted to hear their own voices reproduced through the head-phones.

"Among the passengers was the late James Powers, the Irish comedian. Mr. Powers gave several selections and at the end of one of them gave the date of the recording.

"When I reached my home I could not operate the instrument as my home was

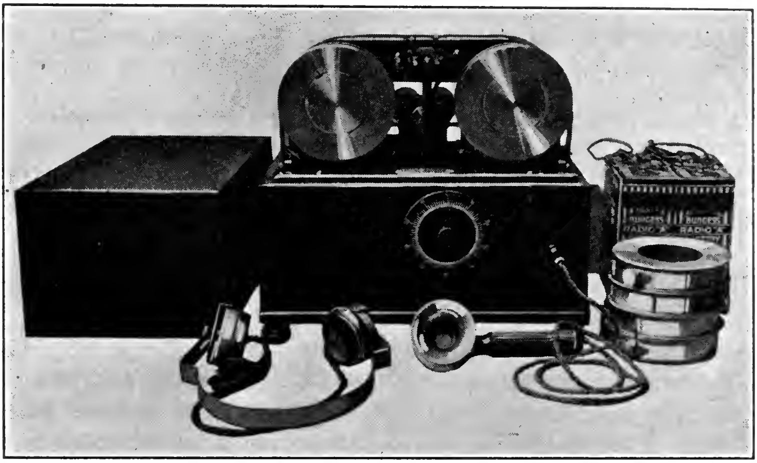

FIG. 1. Mr. Depue's Poulsen telegraphone used for magnetically recording sound on wires in 1907.

not wired with direct current and so the machine has been falling to pieces during these years while lying in my den.

"Mr. Walter Hotz, sound engineer for the Industrial Division of the Burton Holmes Lectures, told me one day that he thought he could trace out the broken circuits of the machine and get it to operate, and that if anything remained of the records he probably could amplify it and reproduce it on film. Thanks to his patience in repairing the machine and in untangling some of the awful messes that the wire reels go into, we have been able to reproduce for you, with ample volume for an audience to hear, those old records. I cannot detect any appreciable loss of characteristics and volume during these 24 years of repose.

"I am sorry circumstances prevented me from attending the convention in person. I should like very much to hear the able papers and discussions and I should like to ask that you consider Chicago for the Fall Convention.

"Now, Mr. Chairman and fellow members of the Society, as usual, I have talked too long and I know you are waiting to hear Mr. Powers give you 'Sally, in Our Alley.'"

The sounds recorded magnetically by the telegraphone, in 1907, to which Mr. Depue referred in his talk, were reproduced from film for the audience to hear. Mr. Depue's talk, reproduced from the continuation the film, was as follows:

"Perhaps you would like to see the telegraphone in operation. To make a recording you touch the forward button; then you plug in the microphone and talk into it at rather close range. Now, to reproduce, you push the stop button and then the 'backward' button, rewinding as far as you wish. Now, remove the microphone plug and start the machine forward. The head-phones will give a reproduction. If you should leave the microphone plug in while reeling forward, any message on the wire would be wiped off. The wire may be used any number of times.

"A look at the inside shows how complicated and delicate it really is. I do not know how it can be used in the industry unless, possibly, for play-backs for a quick check up. But I think this form of machine is far too complicated and the wire too delicate and subject to breakage and tangling to be practical."

REPORT OF THE MEMBERSHIP AND SUBSCRIPTION COMMITTEE*

The present committee, with a slight variation of members, has operated as the Membership Committee since 1928, and has made a thorough investigation of the eligible or potential members in the motion picture engineering field. In 1930 it undertook the work of increasing the number of non-member subscribers to our JOURNAL, and thus became the Membership and Subscription Committee.

The Committee believes that the present entrance fees and dues, as well as the JOURNAL subscription rates, are entirely too high compared with the charges of other societies and the cost of subscriptions for their technical publications. As a result of our high rate of dues, a large number of eligible younger workers are being kept out of the Society. These must resort to reading JOURNALS borrowed from friends, or lack the publications.

As the object of this Society is the dissemination of scientific information, and as the Society has already a number of substantial sustaining members among the manufacturers and producers, we

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

feel that the annual associate dues and the JOURNAL subscription rate should be reduced to such amounts as would permit a greater distribution of the JOURNAL. We feel that the subscriptions for the JOURNAL should not cost more than six dollars per year. At this reduced rate the subscription list could easily be increased to one thousand subscribers within a year.

MEMBERSHIP—MAY 13, 1931

October 1, 1930. Total members (active and associate)		748
Deliquencies from Oct. 1, 1930, to May 25, 1931	90*	
Resignations	22	
Deaths	2	114
Total		634
New members (Oct. 1, 1930, to May 13, 1931)	97	
Applications pending	18	
Total		115
		749

Number of non-member subscribers to the JOURNAL—250.

* Disbandment of the London section resulted in loss of about 60 members in resignations and delinquents or abandonment of membership.

DISTRIBUTION OF THE MEMBERSHIP

Sections or Countries	*Active*	*Associate*	*Total*	
New York Section	195	184	379	
Chicago Section	27	50	77	
Pacific Coast Section	60	53	113	
				569
Argentina		1	1	
Austria		1	1	
Australia	1	3	4	
Canada	6	10	16	
England	19	43	62	
France	10	16	26	
Germany	9	11	20	
Hawaii		1	1	
Holland		1	1	
India	4	10	14	
Italy		2	2	
Japan	2	3	5	
New Zealand		1	1	
Norway		1	1	
Poland	1	2	3	

DISTRIBUTION OF THE MEMBERSHIP

Sections or Countries	*Active*	*Associate*	*Total*	
Russia		2	2	
South Africa		1	1	
West Indies		1	1	
	52	110		162
		Total Membership		731
		Applications Pending		18
				749

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ABSTRACTS

Sensitometric Control in the Development of Sound Films—II. ALFRED KÜSTER AND RICHARD SCHMIDT. *Kinotechnik,* **13,** April 5, 1931, pp. 123–6. Sensitometric control in the development of variable density sound films is maintained by means of an exposing box and an Agfa gammameter. A strip of film is exposed on the box which has a sensitometric scale of five different densities in steps of 0.25. This strip is developed with the sound film and then placed on the gammameter to determine the gamma. This instrument has 12 rows of 5 densities each, corresponding to 12 different gammas, placed over an opal glass illuminated from below. When the film is placed on the gammameter with the densest step on the film over the series of light steps of the gammameter, it is found that the five steps of the film strip assume a uniform density when they cover the five steps of one of the rows of the instrument. The gamma corresponding to this row is then read directly and is the same as the gamma of the strip.

It has been found that with constant development, the gamma of a sound film, as determined by its effect on a photoelectric cell, differs from that of a sensitometric strip measured in contact with an opal glass on account of two effects which act in opposite directions. The first is the Callier effect, as a result of which the sound record has a gamma 1.2 times that of the sensitometric strip. The second is the Schwarzschild effect, resulting from the difference in exposure time and intensity of the sensitometric strip and sound record. This causes the sound film to have a gamma $\frac{1}{1.7}$ as high as that of the sensitometric strip. This factor was found to hold for Agfa 12 developer for a number of varieties of sound film and different development times but is different for different developers. The product of the factors, $\frac{1}{1.4}$, is the factor by which the gamma of the sensitometric strip must be multiplied to find the gamma of the sound record with the same development. This factor is valid for Agfa 12 developer only. M. W. S.

The Problem of Sound Motion Pictures by Radio. FRITZ WINCKEL. *Kinotechnik,* **13,** Feb. 20, 1931, pp. 64–5. A German television receiver serves for the reproduction of standard sound films, since it operates with 1,200 picture elements and 25 pictures per second. The transmitter consists of a sound film projector in connection with a Nipkow scanning disk. The film moves continuously in the projector. It is claimed that the picture quality appears better as a result of the accompanying sound reproduction. Another receiver employs 12.5 pictures per second to conform with the standards of the German Postal Service. The sound accompaniment is said to have a favorable effect upon the picture quality in this apparatus also, although the picture quality is not as good as in the former apparatus. The 12.5 pictures per second are transmitted by the aid of an optical device with mirrors and lenses which combines two succeeding pictures, the combined picture being scanned. The broadcasting of sound films is being considered in Germany. It is hoped that a 42-hole scanning disk instead of

the present 30-hole disk will be employed, and that 25 pictures per second will be sent. Short-wave transmission will be necessary. It is also hoped that the sound film standard will be changed to 25 pictures per second. M. W. S.

A Consideration of Screen Brightness Measurements in Motion Picture Theaters. H. SCHERING. *Kinotechnik*, **13**, Feb. 20, 1931, pp. 59–63. Measurements were made of the intensity of illumination and visual brightness of the screens of eight Berlin theaters and two Dresden theaters. It is concluded that in the projection of black-and-white films on solid screens, great economy of current could be achieved in the smaller theaters by the use of automatic feeding devices for the carbon arcs; that in the larger theaters with screens over 6 meters in width, the projection apparatus installed is hardly adequate; and that in almost all cases the screen is in such poor condition that the minimum screen brightness required is not attained.

Data were obtained for three theaters having porous screens for sound film projection. In all cases, the visual brightness of the screen was far below the required value on account of the poor reflecting power of the screen. The brightness calculated on the basis of a more efficient sound film screen of 65 per cent reflecting power is still too low. In the two larger theaters, it was found that the projection apparatus was inadequate even with efficient adjustment.

On the assumption that color films require twice the illumination required for black-and-white films, it is concluded that the projection apparatus in the theaters having screens 4 meters in width would still suffice for sound films in color, provided that automatic feeding of the carbons were employed. The theaters having screens over 6 meters in width would require a thorough change in the illuminating system in order to effect a material increase in the illumination. This cannot be effected by increasing the current or the aperture of the mirror, and must be done by increasing the intrinsic brightness of the crater. The author concludes that the arcs with high intensity (cored) carbons must be adopted in Germany for the projection of color films. Illustrations are given of American and German high intensity arc lamps for projectors. M. W. S.

A Recent Demonstration of Television and Telecinema. A. LOVICHI. *Technique Cinemat.*, **2**, Mar.-April, 1931, p. 17. A demonstration of the Barthélemy system of television is described. The transmitter employs a Weiller scanning disk, a horizontal wheel carrying on its periphery thirty mirrors inclined at varying angles to the axis. The scanning beam is reflected from these mirrors to the subject and then to the photoelectric cells. There is a brief lapse between the end of one scanning line and the beginning of the next, and these lapses add a 480-cycle frequency to the image modulation. This frequency, filtered by an ingenious amplifying circuit, is used to operate a synchronous motor which drives the receiving scanning disk. The reproducing circuit is not described, but it is claimed that a 3-watt neon lamp is used for a picture area of 600 square centimeters as opposed to a 250-watt lamp for a picture area of 6 square centimeters in the American system. H. P.

Temperature Control during Film Development. T. THORNE-BAKER. *Kinemat. Weekly* (*Supp.*) **172**, June 18, 1931, pp. 41, 43. The importance of accurate control of the temperature during film development is stressed. Equal results may be obtained within the temperature range of 58°F. to 75°F. if the time of development is correspondingly altered in accordance with the temperature co-

efficient of the particular developing agent used. The temperature coefficient is a measure of the relative increase of the velocity of development produced by a rise of temperature of 10 degrees Centigrade (18°F.) and may be obtained from the following relation:

$$\frac{\log t_1 - \log t_2 \times 10}{T_2 - T_1} = \log c,$$

where t_1 and t_2 are the times of first appearance at the Centigrade temperatures T_1 and T_2, respectively, and c is the temperature coefficient. (The terms in the published formula are confused and the substitution given in the example is incorrect, although the correct answer is shown.)

The use of a Dewar flask or thermos bottle is mentioned for the constant temperature development of test strips of film. Electrical heating of the processing solutions may be controlled conveniently by the use of thermostats of the usual mercury contact type or with a Lowry type of tube, which contains in the expansion bulb a liquid of low specific heat and high coefficient of expansion, such as toluine or aniline. With electrical thermostats two stages of relays are necessary, one for the weak thermostat current and a second more robust instrument for the heater current. Heaters of 300 watts capacity per 2 gallon quantity of solution are suggested. The temperature of the solutions may also be controlled by the room temperature, and a brief description is given of methods used by English firms. The necessity for refrigeration during certain seasons is indicated, but no description of equipment is given. L. E. M.

The Trans-Lux System of Operation. GEORGE SCHUTZ AND F. H. RICHARDSON. *Mot. Pict. Herald,* **103,** Sect. 2, May 9, 1931, pp. 12–3. A description of the first of a chain of small theaters seating 150 to 200 patrons. This theater is 45 feet long by 30 feet wide by 14 feet high, and seats 158 persons. Rear projection is used, the projectors being located about 10 feet behind the screen. (The Trans-Lux lens system requires that there be an inch of projection distance allowed for each square foot of projected image.) Horns are located at the sides of the screen. The film is reversed (left to right) before placing in the projector, and the entire sound head is located on the right side of the projector pointing backward. G. E. M.

Recording Processes for Sound Films. *Technique Cinemat.,* **2,** Mar.-April, 1931, pp. 22–39. Descriptions of the following processes are given: Tobis, Gaumont-Peterson-Poulsen, Western Electric, and Stille. Diagrams and illustrations are included. G. E. M.

Natural and Unnatural Synchronism. R. THUN. *Kinotechnik,* **13,** March 1, 1931, pp. 93–5. In natural synchronism, the pictorial representation of the process producing the sound and the reproduction of the sound by the loud speaker have a time relation corresponding to reality; while, in unnatural synchronism, the process apparently producing the sound coincides exactly with the reproduction of the sound by the loud speaker. Some of the principles of synchronizing with a picture speech in a foreign language are described to illustrate the complexity of the time relation between sound and picture that is denoted by the word "synchronism." For a proper artistic effect, natural synchronism is required, and not the unnatural synchronism demanded by hypercritical observers. M. W. S.

The New Sound Film Apparatus of Tobis-Klangfilm for News Recording.

J. KIRSTAEDTER. *Kinotechnik*, **13**, March 1, 1931, pp. 91–3. The motion picture camera and sound recording apparatus are fitted into a large limousine. Pictures may be taken from the moving car, or the camera may be set on a tripod on the ground or on top of the car. Current is supplied by storage batteries. Plate, grid, and Kerr cell potentials are supplied by dry batteries. M. W. S.

The Debrie Sound Film Camera. L. KUTZLEB. *Kinotechnik*, **13**, March 1, 1931, pp. 88–91. The Debrie "Parvo T" camera differs from the previous model "L" principally in having larger film magazines which hold 300 meters of film to meet the requirements of sound films with 24 pictures per second and longer scenes. Upon throwing the switch the motor does not immediately attain its full speed, but reaches full speed very quickly. This is done to avoid straining the mechanism. In the event that the motor should be started when the camera is not ready to operate, or that an accident should occur during operation, a wooden coupling breaks in the driving mechanism between the motor and the camera. Another device stops the motor by electromagnetic means if the film is not fed properly through the gate. Registration marks for synchronizing may be applied at the edge of the film by a lamp or in the picture area immediately below the aperture by means of a punch. In order to reduce noise, the camera housing is lined with rubber, and the gears are constructed of such materials that steel does not work upon steel. A second sound absorbing case covers the entire camera, provision being made for making adjustments on the camera with the case closed. The camera and case are balanced in trunnions on the tripod. A long handle, instead of cranks, serves for panoraming and tilting. The usual form of tripod, with metal braces, is used out of doors, but a heavy column type of stand is used in the studio. One form of studio stand is operated entirely by electric motors. M. W. S.

The Selenophon Recording and Reproducing Apparatus. G. E. ROTH. *Kinotechnik*, **13**, March 1, 1931, pp. 84–8. The Selenophon sound recording apparatus employs a wire under tension between the poles of an electromagnet. When at rest, the wire covers half the light image of a slit. When current from a microphone flows through the wire causing it to vibrate, it uncovers more or less of the slit image. The device may be used for either the variable width or variable density method of sound recording. In the variable width method, the wire is placed at a slight angle to the slit, so that the length of the slit image changes. In the variable density method, the wire is placed parallel to the slit so that the width changes. In practice, the Selenophon Company uses the variable width method. Eight sound records are made in the width of a 35 mm. film.

The reproducing apparatus employs a selenium cell of the condenser type. In this cell a condenser is cut perpendicularly to the plates so that the edges of the interlocking plates are exposed. A thin layer of selenium forms a conducting medium between the edges of the plates. This device is built into apparatus that can be attached to a standard motion picture projector.

The Selenophon Company also makes three models of apparatus for reproducing sound without pictures for home use. M. W. S.

Notes on Loud Speaker Response Measurements and Some Typical Response Curves. BENJAMIN OLNEY. *Proc. I. R. E.*, **19**, No. 7, July, 1931, p. 1113. The difficulties encountered in the measurements of loud speaker output are de-

scribed. A typical set-up for taking curves indoors is explained. Greater accuracy of measurement, especially in the low-frequency range, is obtained by making measurements out of doors. An out-door set-up for making loud speaker output measurements is explained and illustrated. The effects of various corrugations in loud speaker cones, and the effects of different types of baffles are illustrated by numerous curves. The interpretation of loud speaker response curves is shown to be a comparative interpretation rather than a direct reading of what one may expect to hear. A. H. H.

High Audio Power from Relatively Small Tubes. L. E. BARTON. *Proc. I. R. E.*, **19,** No. 7, July, 1931, p. 1131. The reasons for the development of the present power output tubes are pointed out. Class "A" amplifiers are explained as well as the factors limiting the power output of such amplifiers. It is shown that the output load resistance for maximum undistorted power output is a function of the plate current and plate voltage, and is practically independent of the plate resistance and amplification constant, provided the grid swing is not limited. The principles of operation of class "B" audio amplifiers are thoroughly explained with the aid of numerous diagrams. The power output of a class "B" amplifier is limited only by emission or plate dissipation on peak signals. For class "B" amplifiers the bias supply must be well regulated or batteries must be used. A. H. H.

The Prevention of Interfering Noises. P. T. SHERIDAN. *Motion Picture Herald*, Section 2, July 4, 1931, p. 31. This article, the first of three on this subject, although non-technical, is of interest to the engineer. It covers those noises which are transmitted through the air to the theater audiences. Several sources of noises and possible corrective measures are given. Projectionists' conversations, loud operation of the monitor speaker, handling of film, poor reels, and noises from the projection machine itself are mentioned as possible sources of this type of noise. A. H. H.

The Measurement of Reverberation Time and Its Application to Acoustic Problems in Sound Pictures. F. L. HOPPER. *J. Acoustical Soc.*, **II,** No. 4, April, 1931, pp. 499–505. A reverberation time meter is briefly discribed. The results of typical measurements are shown, including the reverberation time *vs.* frequency curves of two sound stages, a theater before and after acoustical treatment, and the absorption-frequency characteristics of acoustic building board and rockwood. W. A. M.

A Direct Reading Audio-Frequency Phase Meter. W. R. MACLEAN AND L. J. SIVIAN. *J. Acoustical Soc.*, **II,** No. 4, April, 1931, pp. 419–33. A direct reading audio-frequency phase meter, which includes a cathode ray oscillograph and special vacuum tube circuit, is described. As an illustration of the type of work to which this phase meter is well suited, an acoustical experiment is described in which the response *vs.* frequency and phase angle *vs.* frequency of each of two microphones, hung indoors, are measured in detail between 1,500 and 1,505 cycles per second. Their combined outputs are also studied and show, in this particular case, a variation of almost 30 db. in response and a variation of over 100 degrees in phase angle within this frequency band only five cycles wide. W. A. M

A New High Efficiency Theater Loud Speaker of the Directional Baffle Type. HARRY F. OLSON. *J. Acoustical Soc.*, II, No. 4, April, 1931. A description

of a new directional baffle speaker together with a theoretical discussion of design. Curves showing the efficiency *vs.* frequency, response *vs.* frequency, and directional properties of the speaker are included. W. A. M.

Sound Pictures: Fundamental Principles and Some Factors Which Affect Their Quality. F. L. Hunt. *J. Acoustical Soc.*, **II,** No. 4, April, 1931, pp. 476–84. This paper reviews the fundamental principles of sound picture recording and reproduction on disk and film, showing that sound pictures in the modern sense were dependent on the development of the vacuum tube amplifier which made available adequate energy for recording and reproduction, and also on the use of electrical methods of synchronization and speed control. The present status of the art relative to frequency and volume ranges and the effect of limitations in these factors on quality is then discussed. The effect of reflected sound reverberation on the fidelity of recording in the studio and on reproduction in the theater is also considered. The best articulation is obtained when reflected sound is not present, but some reflection is usually necessary to maintain the illusion that the sound was produced under the conditions depicted in the scene. The high per cent of articulation obtained by experiment with standard reproducing equipment indicates that little difficulty should be experienced in understanding as far as equipment is concerned. This shows the importance of good auditorium acoustics. W. A. M.

Acoustics of Music Rooms. Vern O. Knudsen. *J. Acoustical Soc.*, **II,** No. 4, April, 1931, pp. 434–67. This paper "represents an attempt to consider the problem of music room acoustics in the light of recent developments in acoustics and the tested results of experience; and to call attention to certain problems which require further investigation." The ideal conditions for the artistic production of music and the conditions for listening to music are listed and discussed. These include freedom from noise; the proper arrangement of spaces for orchestra, soloist, chorus, organ, and audience; proper loudness; proper reverberation characteristics; resonance; echoes, interfering reflections and sound foci; and variation of the acoustical properties of a room with the size of the audience.

A section is devoted to data recently collected by the author regarding the acoustics of thirteen European music rooms. The many factors affecting the acoustics of these, of which the reverberation time of each is only one factor, are weighed and discussed. The apparent need for resonant panels of wood or plaster, or both, as a part of the ideal music room, is emphasized. The data also indicate that the reverberation times of those music rooms which enjoy the best reputations are shorter than have generally been accepted as optimal in the past. An example of the general point of view of the author is illustrated as follows: "Here, as in the Musikvereinssaal, good acoustical properties are identified with rather short reverberation times (1.35 and 1.5 seconds at 512 d.v., and about double these values at 128 d.v.), with shapes that are free from pronounced concave surfaces, and with rooms that are bounded, in large part, with resonant materials. It should be mentioned also that both halls are remarkably free from outside noises."

A very practical conclusion to the paper is given in four illustrations giving plans of four music rooms, varying in size from a small music studio to an opera house, such that they embody the desirable features of design advocated in the text. W. A. M.

BOARD OF ABSTRACTORS

ABSTRACTS OF RECENT U. S. PATENTS

Reissue 18,108. **Producing Silent Intervals on Sound Tracks.** Lee de Forest. Assigned to General Talking Pictures Corporation. June 23, 1931. Silent intervals may be produced on the photoelectric sound track of a sound-on-film positive and the sound track freed of any densities in the emulsion of the film that may produce ground noises by blackening the positive at all portions of the sound recording part of the film where silence is desired. The developed sound-on-film negative produces a sound track on a positive film and the two films are run through a printer where an auxiliary printing light produces a blackened interval on the positive film where silence is desired.

In order to blacken the positive film at appropriate intervals the negative or master film is provided with notches at those portions where a blackened positive is to be produced. These notches serve to control the operation of a switch which cuts on or off the auxiliary printing light to produce the silent portions of the positive film.

1,809,815. **Safety Device for Motion Picture Projecting Machines.** J. F. Adams. Assigned to Sentry Safety Control Corp. June 16, 1931. Safety cut-off and douser for protecting the film against ignition in the event that the driving motor on the projector should drop below a predetermined speed. A mercury switch is provided for interrupting the motor circuit when the speed falls below a predetermined value. A shutter is also electromagnetically actuated for obstructing the rays of light passing through the film when the speed falls below a safe value.

1,809,816. **Centrifugal Switch for Controlling Film Feeding Mechanism.** J. F. Adams and Thomas T. Allen. Assigned to Sentry Safety Control Corp. June 16, 1931. The film feeding mechanism is controlled by means of a centrifugal switch. The centrifugal switch has contactors which, when the film feeding mechanism and switch are operated at a predetermined speed, are held outward centrifugally. However, when the film feeding mechanism and switch fall below the required speed, the contactors are swung inward and make contact with the contact rings which break the motor circuit, and stop and intercept the light rays upon the film. By means of the centrifugal switch the proper filming may be controlled.

1,809,817. **Safety Unit for Motion Picture Projectors.** Thomas T. Allen and John F. Adams. Assigned to Sentry Safety Control Corp. June 16, 1931. A safety switch for motion picture projectors which operates if the film fails to move at or about a certain speed through the path of the rays of light emanating from the projection lamp to cut off the light rays and bring the projector to a stop. A unit is provided for stopping the projecting mechanism and intercepting the rays of light passing through the film upon the occurrence of any incident or accident which might cause the film to ignite. The safety device includes an electromagnet, a relay system, and a centrifugal switch electrically connected with the motor circuit and arranged to control a shutter mechanism for insuring

the safety control of the projector in the event of an accident giving rise to fire hazard.

1,810,002. **Film Marking Device.** JOHN ARNOLD. Assigned to Metro-Goldwyn-Mayer Corp. June 16, 1931. An auxiliary shutter is mounted upon a motion picture camera and operated by an electromagnet for exposing the film at selected time intervals with light for marking the film at any given position. The arrangement of the auxiliary shutter and electromagnetic actuator is very compact, for placing a light spot on the film to form an identification means for that portion of the film after development.

1,810,062. **Wax Record Synchronized by Timing Strip on Film.** E. R. TAYLOR. June 16, 1931. A wax record type of phonograph is used in coöperation with a motion picture projecting machine and synchronized in operation by a timing strip which runs in synchronism with the picture film. The timing strip carries contact members at predetermined intervals adapted to close a circuit to an electromagnetic actuator for engaging or disengaging the stylus with the sound record in timed relation to the movement of the picture film.

1,810,168. **Motion Picture Screen Employing Embedded Glass Cylinders.** J. A. GRAY. June 16, 1931. A covering layer of solid glass cylinders is imbedded in and applied to an adhesive coating on a fabric backing, which forms the motion picture screen. The solid glass cylinders are approximately $^1/_{64}$ of an inch in diameter and about $^1/_{16}$ of an inch long. These glass cylinders constitute the facing of the screen, lying in all sorts of varying flat-wise positions upon the fabric, and the light thrown against the face of the screen is condensed in the usual manner and reflected therefrom at the different angles of both the end walls and the circular walls of the cylinders. The end walls of the cylinders face other adjacent cylinders at all sorts of varying angles and there will be an extreme variation, both of the angles of the rays of reflection and of the angles of the rays of refraction in rays passing from one cylinder to another cylinder and being then reflected and refracted. Since the light is reflected and refracted at every conceivable angle, the field of illumination is materially spread beyond the sides of the screen.

1,810,169. **Backing for Motion Picture Screen.** J. A. GRAY. June 16, 1931. A projection screen for talking motion pictures where a porous backing member is provided for the free passage of sound from a sound reproducer in the rear of the screen through the screen. The threads of the backing member are coated with a pigment compound and then a layer of small cylindrical glass particles deposited over the compound. The glass cylinders serve to increase the lateral diffusion while permitting the free passage of sound through the screen.

1,810,188. **Television System.** T. A. SMITH. Assigned to Radio Corporation of America. June 16, 1931. Transmitting system for televising motion pictures, where the number of complete television images to be transmitted per second is different from the number of frames on the transmitted film which normally pass the projector aperture or scanning device in the same period of time. The motion picture film is, in effect, transmitted over a television transmitter at a speed lower than that at which it was originally made to be run, while, at the same time, the sounds accompanying the film may be transmitted at the proper speed for which it was originally produced. The scanner is operated in conjunction with a shutter mechanism by which a motion picture film may be moved at a predeter-

mined constant speed relative to a predetermined point and a smaller number of picture frames of the motion picture film scanned than the number of picture frames which pass before the predetermined point during a unit time period.

1,810,200. **Printing Machine for Colored Films.** P. BROSSE. Assigned to Kislyn Corporation. June 16, 1931. A projection printing machine for reproducing color prints on film according to the Berthon process. Essentially, the apparatus comprises a conventional projection printing machine which is provided with two passing devices whereof the mechanisms have a reversed action with respect to each other; in the one the original film is passed downward; in the other the copy is passed upward. Between these mechanisms is located the optical system by means of which the original film is projected on the virgin film by means of a light source illuminating the original film.

1,810,234. **System for Optically Recording Phonograph Records.** Assigned to Radio Corporation of America. June 16, 1931. A diaphragm is arranged to be moved in accordance with sound vibrations, and is linked to variably tilt a reflecting mirror in accordance with variations in the amplitude of the sound vibrations. The reflected light is directed toward a rotatably mounted light-sensitive disk by which a trace may be made on the light-sensitive disk. The light-sensitive disk is mounted on a carriage adjustable toward or away from the movable mirror. The disk is rotated by a gear system which meshes with teeth formed in the peripheral edge of the rotatable carrier for the disk.

1,810,324. **Multiple Channel Sound Reproducing Apparatus.** F. H. OWENS. Assigned to Owens Development Corp. June 16, 1931. A multiple channel sound film is employed wherein one channel contains a sound record including sound within a particular range of frequencies, while the other channel contains sounds within a different range of frequencies. Separate photoelectric cells with control circuits connected thereto are aligned with the different sound channels and connected to a sound reproducer circuit. A shutter mechanism containing apertures adapted to be aligned with either of the sound channels and the associated photoelectric cell is arranged adjacent the film and is driven by a solenoid which is energized from a switch automatically actuated by an arm engageable with notches cut at predetermined points along the edge of the film. The notches are so arranged along the film that the shutter mechanism may be shifted from one position to another to select the order of reproduction on the different sound films.

1,810,346. **Motion Picture Screen for Stereoscopic Effect.** E. M. CRAWFORD. June 16, 1931. Motion picture screen formed of sections which are adjustable along a transverse axis into different planes of rotation for the reproduction of a picture which will have a stereoscopic appearance. The different sections of the screen are adjustable transversely with respect to a central rotatable shaft which will provide different angularly disposed display surfaces for the picture. As these surfaces are rotated at a rate of 16 rotations of more per second the illusory effect of two visible screens, one behind the other, will be created and the projected pictures will be seen on both screens, thus giving a depth, or stereoscopic effect.

1,810,348. **Douser Control Mechanism for Motion Picture Projectors.** J. T. FEWKES. Assigned to Sentry Safety Control Corporation. June 16, 1931. An electromagnetic actuating device which normally holds a shutter out of the

light-obstructing position when the electromagnetic device is energized during the normal operation of the projection machine. However, in case of defective filming, such as breaking or clogging of the film, the electromagnetic actuator acts to automatically shut off the passage of light rays and to open the circuit of the driving motor. After correction of the defect, the douser is automatically re-set in the safety position for a successive operation.

1,810,605. **Modulating Light Beam by Variation of Air Density Caused by Sound Waves.** H. P. HOLLNAGEL. Assigned to General Electric Company. June 16, 1931. A beam of light is focused to pass through a point of concentration. Sound waves are directed upon the beam of light at the point of concentration thereof for modulating the light rays. The light rays may be focused upon a film and modulated in accordance with the impression of sound waves at the point of concentration of the light beam. In order to concentrate the sound waves a conical shaped member is arranged to lead the sound waves to the small open end, and at the focal point of the light beam where the density of the air is changed to produce corresponding variations in the refraction of the light beam at that point.

1,810,703. **Blue Color Filter for Kerr Cell Employing Nitrobenzol.** W. GALLAHAN. Assigned to Westinghouse Electric and Manufacturing Company. June 16, 1931. A Kerr cell utilizing nitrobenzol for its dielectric is employed to control the passage of light to the light-sensitive film during the recording process, and a color filter transparent to blue light is interposed in the path of the light rays. The color filter, which is transparent to blue light, compensates for the yellow color of the nitrobenzol. The nitrobenzol has a natural yellow color which tends to increase the blurring effect of yellow light on the film. However, with a color filter transparent to blue light, such as a piece of gelatin dyed blue by means of aniline dye, this blurring effect is counteracted.

1,810,705. **Thermal Sound Recording System.** E. H. HANSEN. June 16, 1931. Recording apparatus for impressing sound on wax records where the recording head functions with a preformed disk for engraving a sound record in the disk by a thermal process. The recording stylus is electrically heated for thermally cutting a record in the disk in accordance with sound variations.

1,811,365. **Roller Support for Traveling Films.** F. H. OWENS. Assigned to Owens Development Corporation. June 23, 1931. A sound and picture film is guided over a fixed arbor which has rotatable sleeves journaled thereon for providing a support for the film during the passage of the film over the arbor. The rotatable sleeves extend toward each other along the arbor and are separated by a predetermined gap. An aperture extends diametrically through the arbor in the gap formed between the ends of the sleeves, and provides a light passage for the light rays which pass through the sound channel on the film for actuating a photoelectric cell aligned with the aperture through the arbor.

1,811,495. **Multiple Image Camera.** H. N. COX. Assigned to Cox Multi-Color Photo Company. June 23, 1931. A lens system wherein multiple-image work may be substituted in a camera for the usual single-image lens and when so substituted is capable of affording a plurality of images in which aberration due to parallax as well as to the optical properties of the lenses is not greater than the aberration which in the single-image system is due solely to the optical properties of the lens. The multiple-image lens projects the light upon a film within the

area covered by the single-image lens, providing multiple images of equal angle of view. The multiple-image lens system includes a plurality of identical lens units, and a fixed aperture symmetrically spaced about an axis, the focal length of the lenses being substantially $5/8n \times w$, in which n equals the numerical aperture of the lens units of the multiple-image system, and w equals the width of the film area.

1,812,068. **Footage Indicator for Motion Picture Cameras.** A. F. VICTOR. June 30, 1931. Scale for indicating the amount of unused film remaining on the reels of a motion picture camera. A scale is provided which contacts with the film reel and shifts in accordance with the delivery of the film from the reel to render visible calibrations on the scale which indicate the amount of unused film still on the reel.

1,812,212. **Fire Shutter for Motion Picture Projector.** W. H. MEYER. June 30, 1931. A fire shutter for motion picture projectors in which the shutter is perforated over its entire area. The perforations in the center of the fire shutter are smaller than the surrounding perforations and graduate in size as they extend outward from the center of the fire shutter. This form of fire shutter is particularly adapted for home type motion picture machines. The shutter is automatically positioned in the path of light rays between the lamp and the film when the projector is stopped and positioned away from the path of light rays when the projector is operated and the film is in motion.

1,812,303. **Elongated Light-Sensitive Element for Reproducing Sound.** F. H. OWENS. Assigned to Owens Development Corporation. June 30, 1931. An elongated light-sensitive element is used for translating modulated light rays into electrical impulses. The light rays are spread during their passage to the light-sensitive element so that the light rays will enter the element over substantially its entire length, thus producing a maximum volume of reproduced sound. An elongated housing is provided for the light-sensitive element which provides for the reflection of light rays to secure maximum illumination of the light-sensitive element.

1,812,402. **Electroöptical Transmission System.** F. GRAY. Assigned to Bell Telephone Laboratories, Inc. June 30, 1931. An apparatus for producing television images, comprising a spirally arranged row of primary sources of light, such as electric lamps, attached to a revolving disk near the periphery thereof, and adapted to cross the field of view in succession to build up an image. Each lamp is connected to a circuit including a winding attached to the disk through which the lamp is inductively energized, while passing across the field of view, by a source of image current having variations corresponding to the tone values of successively scanned elemental areas of a field of view. The image current may be a current of varying amplitude which is supplied directly to the lamps through an inductive coupling.

1,812,405. **Multiple Channel Electroöptical Transmission System.** H. E. IVES. Assigned to Bell Telephone Laboratories, Inc. June 30, 1931. This invention provides for splitting the total scanning frequency band of the photoelectric signal current into a number of narrower frequency bands or sections by means of filters or the like, so that the different sections may be segregated for any purpose, such as transmission over different circuits. The low energy gaps between the groups of frequency components permit the composite current re-

sulting from scanning to be so divided without interfering with essential frequencies. When the narrow or sub-groups are transmitted over separate channels or circuits, respectively, each circuit may have transmission characteristics suitable for the transmission of one of the sections of the photoelectric current, the splitting being made in the above-mentioned gaps; or each segregated section or band of frequencies so split may be transposed by combination, respectively, with suitable currents of different constant frequencies, to the same or different part of the frequency spectrum for transmission over different circuits having similar or suitable characteristics, thus permitting the use of comparatively low-grade circuits or circuits having a comparatively limited frequency range. The different sections, after being transmitted, may be restored to their original frequency position; thereby producing a signal current corresponding to the original photoelectric current.

1,812,763. **Photoelectric Cell Bridge for Measuring Light Intensity.** W. E. STORY, JR. Assigned to General Electric Company. June 30, 1931. The intensity of light from two sources may be compared by placing a photoelectric device in each of two arms of a Wheatstone bridge; and the illumination from any lamp may be compared with that from a standard lamp in such a way as to avoid the visual comparison of illumination. The photoelectric cells which are exposed to the sources of light are employed to accurately change the resistance of the Wheatstone bridge circuit for operating a calibrated indicator.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

BOOK REVIEW

Seeing—A Partnership of Lighting and Vision. M. LUCKIESH, Director, Lighting Research Laboratory, General Electric Co., Nela Park, Cleveland, AND FRANK K. MOSS, also of the Lighting Research Laboratory, Nela Park. *Williams & Wilkins Co.*, Baltimore, Md. 241 pp. 63 illustrations; also an illustrated supplement, "A Demonstration Visual Test." $5.00. This book represents an attempt to strike a new note in the science of lighting and as such, goes beyond the usual work on illuminating engineering. While much data of the usual variety have necessarily been included, the aim is primarily to interpret their influence in determining the ability to see well. Consequently, such important factors as visual acuity, contrast, brightness adaptation, and glare are discussed in considerable detail in relation to the speed and accuracy of vision. There has been included much laboratory information along this line that is not available in the previous works on lighting, and which adds considerably to the value of the book.

Two very useful chapters deal with brightness and the speed of seeing. The former explains in a simple manner how brightness influences visual acuity in relation to threshold values and contrast, and the two chapters together cover the relation between these factors and the speed with which one can distinguish test objects. Another important chapter deals with the speed of adaptation and the necessity for proper transition lighting in passing from brilliantly illuminated places to darker ones, as from outsides to interiors. Other subjects covered in some detail are glare and visibility, spectral character of light, and the nature and prevalence of subnormal vision. Enough data on the present standard practice in illuminating engineering have been included in the book to make it a comprehensive survey of the subject, and to make it useful to anyone concerned with practical applications. At the end there are a number of charts illustrating the relationships discussed previously. In the supplement there are over twenty charts and figures which, together with an explanation, comprise a visual test to be used as a practical demonstration of the value of better lighting. The book as a whole should prove valuable to anyone who is at all interested in the subject of "Seeing."

E. F. KINGSBURY

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CONTRIBUTORS TO THIS ISSUE

Baker, F. F.: Born April 10, 1890, at Hamburg, Iowa. Tabor College. Motion picture cameraman since 1911; specialist in trick and miniature photograpy, 1921–29; Technicolor Motion Picture Corp., 1929–31.

Ceccarini, O. O.: Born March 21, 1894, at Montefiascone, Italy. Physics and mathematics, Technical Institute, Rome, Italy; post-graduate work, Union College. Testing and general engineering departments, General Electric Co., 1915–19; research engineer, Bell Telephone Laboratories, 1920–27; assistant chief engineer, Vitaphone Corp., 1927–28; development engineering, Metro-Goldwyn-Mayer Studios, 1928 to date.

Falge, F. M.: Graduate U. S. Naval Academy, 1924; sales department, Westinghouse Electric & Mfg. Co. 1924–26; engineer, National Lamp Works Nela Park, 1926–28; lighting specialist, production and research departments, Paramount Publix Corp., 1928–30; instructor, Paramount Theatre Managers Training School, 1930; engineer, Beaded Screen Corp., 1931.

Felstead, C.: Born December 21, 1902, at Buffalo, N. Y. University of Southern California, 1924–28; in charge of construction and operation of limited commercial radio stations, Thos. H. Ince Studio, 1923–24; research laboratory, Gilfillan Radio Corp., 1928; supervising construction and installation of radio stations, Universal Pictures Corp., 1928; sound engineer, Universal Pictures Corp., 1928 to date.

Hoke, I. B.: Born May 26, 1894, at Rock Island, Ill. Motion picture photographer, 1927; photographer, Signal Corps, U. S. Army, 1927–19; free lance motion picture photographer, 1919 to date.

Kuhn, J. J.: Born 1891, at Elizabeth, N. J. Power transmitting machinery department, A. &. F. Brown Co., 1909–19; engineering department, Western Electric Co., 1919–25; in charge of mechanical design of Public Address and Program Supply Systems, Deaf Aids, Sound Picture Equipment, Bell Telephone Laboratories, 1925 to date.

Physioc, L. W.: Born June 30, 1879, at Columbia, S. C. College of Agricultural and Mechanical Art, Raleigh, N. C.; Cooper Institute, New York, N. Y.; experimental work with Thomas A. Edison, four and one-half years; at Scenic Studios, eight years; art director, Pathé Studios, two years; student at New York School of Art, National Academy of Design, Art Students' League, Architectural League; cameraman; director of photography, Goldwyn Company, four and one-half years; superintendent, Consolidated Laboratories, two years.

Westerberg, F.: Born February 2, 1894, at San Francisco, Calif. B.S., School of Forestry, University of Washington, 1916. Laboratory, Lasky Studio, 1916–17; ensign, U. S. N. R. F., 1918; camera department, Paramount Lasky Studio, 1919–25; camera department, Cecil B. de Mille Studio, 1925–28; in charge camera department, United Artists Studio, 1928–30.

SOCIETY ANNOUNCEMENTS

THE FALL CONVENTION

At a meeting of the Board of Governors held in the Hotel Van Curler, Schenectady, N. Y., August 10, 1931, the location for the Fall 1931 Meeting was determined and various details pertaining to the meeting were discussed and arranged. Due to the fact that the membership has shown a preference for holding the fall meeting at a place removed from large metropolitan centers in order to foster and promote the social aspects of the convention, it was decided to hold the convention at Swampscott, Mass., from October 5th to 8th, inclusive, with headquarters at the New Ocean House.

Full details of the convention will be found in the Arrangements Program on page 479 of this issue of the JOURNAL, together with descriptions of the transportation facilities, points of interest, amusements, *etc.*

A final program of the meeting is being arranged by the Convention Committee, which will be mailed to the membership in the near future, and an attractive program of papers is being arranged by the Papers Committee. An exhibition of newly developed motion picture apparatus, similar to the exhibition held at the recent Hollywood meeting, will be held in the Colonial Room of the hotel.

NOMINATIONS OF OFFICERS

Nominations of officers to be elected at the forthcoming Fall Convention were held at the August 10th meeting of the Board of Governors at Schenectady. Voting ballots will be mailed to the membership as soon as the acceptance of the nominations by the nominees is assured, and announcement of the results and the installation of the officers-elect will be made at the Fall Meeting at Swampscott.

ABRIDGEMENTS OF PAPERS

The Board of Governors, at the meeting of August 10th, ruled that "the Chairman of the Publicity Committee is authorized to distribute

abridgements of papers presented at meetings of the Society, prior to the publication of these papers in the JOURNAL, to the extent of twenty per cent of the material contained in each paper. Such abridgements can be obtained only from the Chairman of the Publicity Committee."

CREDIT FOR REPRINTS

The Board of Governors also ruled that "papers appearing in the JOURNAL or presented at meetings of the Society may be reprinted and abstracted or abridged provided credit is given to the JOURNAL of the Society of Motion Picture Engineers and to the author or authors of the papers in question."

THE HOLLYWOOD CONVENTION

The following letter was distributed to the members of the New York Section shortly after the recent Convention at Hollywood, Calif. Although an account of the Convention was given in the July issue of the Journal, the following is presented in order to furnish a different viewpoint for those who were unable to attend the meeting.

TO THE MEMBERS OF THE NEW YORK SECTION:

It had been planned to hold a meeting of the Local Section at which reports of the Hollywood Convention could be made, but due to various conditions, it has been impossible to arrange such a meeting. The next meeting of the New York Section will be held about September 20, 1931.

I have therefore prepared this short report of the Hollywood Convention for circulation among the members of the New York Section, as I thought it might prove interesting to them.

The Convention sessions were held in the very beautiful hall of the American Legion Auditorium. The latest type of sound projectors had been installed, and the whole program was characterized by the excellent showmanship exhibited by the Hollywood members of our organization. Everything went off with perfect precision and there were no waits or delays to mar the occasion.

A very interesting exhibit of new apparatus was arranged in a hall of the same building, and several new cameras, moviolas, various types of lighting equipment, reflectors, *etc.*, were shown. This exhibit attracted a large attendance, and as each exhibit was manned by competent technical experts, a great deal of information was available at first hand; and this helped to make the show a great success. The registration at the Convention included about three hundred members of whom about seventy-five were from the East.

Among the notable papers which were presented were the following:

Mr. Ben Schlanger, of New York, read a very interesting paper on a suggested new design for theaters. The important feature of this design is that the audience enters the theater on the street level, passing down a few steps to the orchestra floor, and up a few steps to the balcony floor. A very novel arrangement of seats is provided, so that each person in the audience sits in such a way that he looks directly at the center of the screen without having to bend over or assume an uncomfortable position in order to get a proper view of the screen. There was a great deal of discussion on this paper and the general opinion is that it offers great possibilities for improvements in theater design.

A symposium on color photography was held on Monday afternoon, presided over by Dr. Mees. A number of interesting examples of various color processes were shown, which were interesting in themselves as well as in illustrating the latest advances in color photography.

Tuesday morning was devoted to a symposium on sound recording, and resulted in the usual active discussions on the various methods that are being employed.

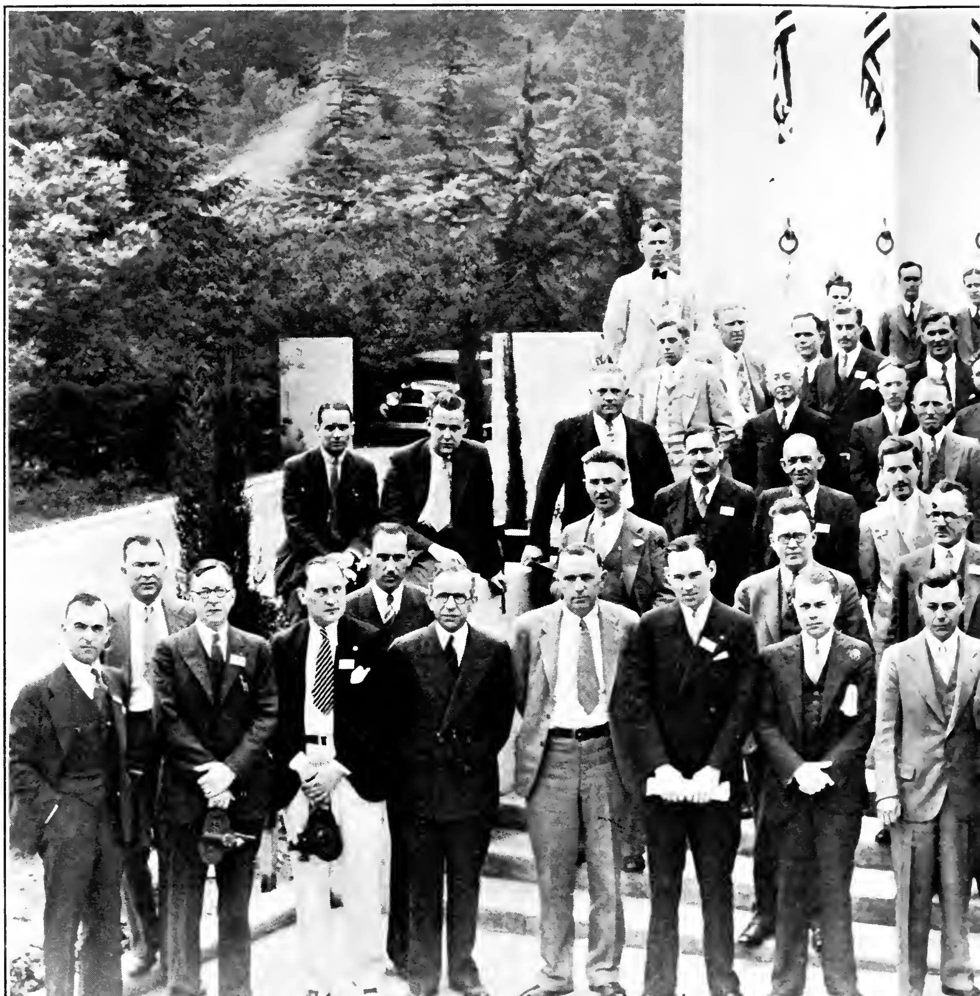
One of the very interesting papers of the Convention was a rather lengthy one, by Mr. L. A. Jones of the Eastman Kodak Company, on "Sensitometry." On account of the length of this paper it was read in three separate parts at different times.

Mr. Crabtree awarded a prize at the end of each session to the person who presented his paper in the most interesting manner. This created a little competition among the readers of the papers, and helped to make the program more interesting.

Screen demonstrations were given of examples of the new du Pont and Eastman high-speed negative films. The new Eastman film, in addition to being about 100 per cent faster than the old film, is coated on a so-called gray base which has a noticeable effect in eliminating halation.

The cameramen came out almost in a body, and made a strong appeal for a silent camera with a standard aperture and a standard motor.

Several new advances in cameras were shown, including the new Moreno-Snyder continuous camera which is equipped with a photoelectric cell for determining exposure. The new Mitchell sound camera was also shown.



Visits were made to the Paramount and Fox Studios on different afternoons, and many new types of apparatus and methods of operation were shown.

Dr. Donald A. MacKenzie read a very interesting paper on straight-line and toe records with a light valve. This paper will be well worth studying.

A paper by Mr. Roy Hunter describes a suggested new method of making release prints, which is essentially as follows: a positive is made from the original negative, and this positive is used to make succeeding release prints by the usual printing method; these prints are reversed in development, thus converting them into positives.

Mr. E. H. Dunning gave a very interesting talk on the Dunning process and process backgrounds, and described in detail the use of the Dunning process in making foreign versions.

A new 35 mm. portable sound projector was described and shown by Mr. H. Griffin. This projector is remarkably silent in operation, and simple in construction.

A new newsreel camera was described by Mr. J. L. Spence. The camera has many novel features, and gives to the newsreel cameraman a camera designed primarily for sound picture work.

The Convention session lasted for five days; in fact, the last paper was read at 11:30 P.M. on the last day of the session. The Convention was somewhat of an endurance contest, but many worth-while papers were read, and those who attended were amply repaid for their efforts in getting to the Convention.

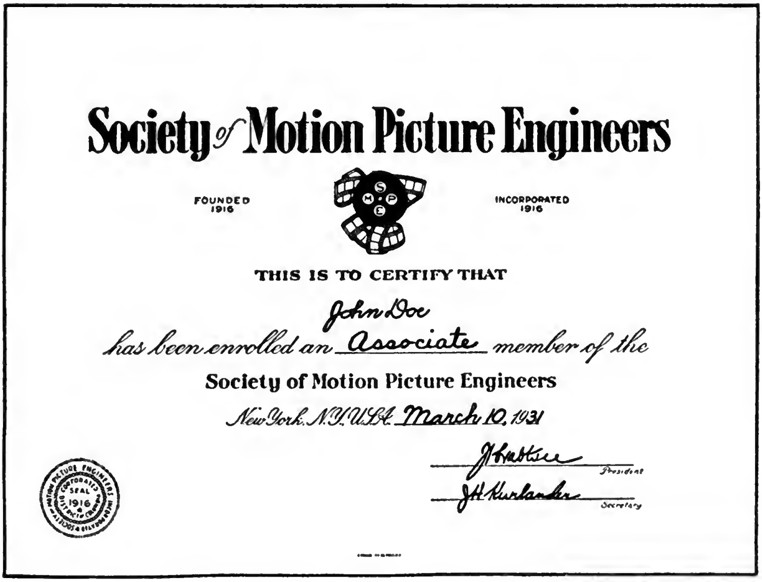
M. W. PALMER, *Chairman*

LAPEL BUTTONS

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of one dollar.

MEMBERSHIP CERTIFICATE

Associate members of the Society may obtain the membership certificate illustrated below by forwarding a request for the same to the General Office of the Society at 33 W. 42nd St., New York, N. Y., accompanied by a remittance of one dollar.


Society of Motion Picture Engineers

FOUNDED 1916 INCORPORATED 1916

THIS IS TO CERTIFY THAT

John Doe

has been enrolled an Associate member of the

Society of Motion Picture Engineers

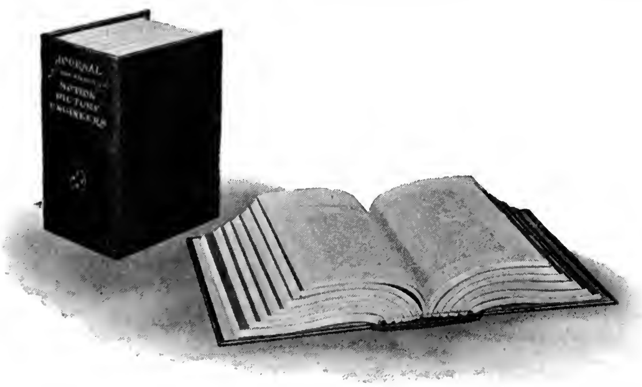
New York, N.Y. U.S.A. March 10, 1931

President

Secretary

BINDER FOR JOURNALS

The binder shown in the accompanying illustration serves as a temporary transfer binder or as a permanent cover for a complete



year's supply of JOURNALS. It is made of black crush fabrikoid, with lettering in gold. The binder is so constructed that each individual copy of the JOURNAL will lie flat as its pages are turned. The separate copies are held rigidly in place but may be removed or replaced at will in a few seconds.

These binders may be obtained by sending your order to the General Office of the Society, 33 West 42nd Street, New York, N. Y., accompanied by a remittance of two dollars. Your name and the volume number of the JOURNAL may be lettered in gold on embossed bars provided for the purpose at a charge of fifty cents each.

ARRANGEMENTS PROGRAM

FALL MEETING OF THE SOCIETY, NEW OCEAN HOUSE SWAMPSCOTT, MASSACHUSETTS

(October 5–8, 1931, inclusive)

The following committees and individuals will officiate during the convention:

COMMITTEES IN CHARGE OF ARRANGEMENTS

BOSTON LOCAL COMMITTEE

J. S. CIFRE, *Chairman*
A. C. HARDY
C. A. B. HALVORSON
L. T. TROLAND
A. J. HOLMAN

RECEPTION

J. S. CIFRE	A. C. HARDY	C. A. B. HALVORSON
L. T. TROLAND	A. J. HOLMAN	A. C. HAYDEN
J. K. KIENNINGER	THAD. C. BARROWS	J. H. COHEN
DONALD MCRAE	H. S. DILL	JOSEPH ROSEN
LEROY ANDREWS		MAURICE ROTTENBERG

CONVENTION REGISTRARS

W. C. KUNZMANN	H. T. COWLING
S. RENWICK	E. R. GEIB

BANQUET ARRANGEMENTS

W. C. HUBBARD, *Chairman*

W. C. KUNZMANN F. C. BADGLEY J. S. CIFRE

BANQUET AND DANCE

Banquet: Main dining room, New Ocean House, promptly at 7:30 P.M., Wednesday, October 7, 1931.

Dancing: Ballroom, New Ocean House, immediately following the banquet.

Banquet tables for six or eight persons can be reserved at the registration desk. These reservations close at noon on Wednesday, October 7th.

SUPERVISORS OF PROJECTION EQUIPMENT, INSTALLATION, AND OPERATION

H. GRIFFIN, *Chairman*

J. FRANK, JR.

Officers and Members of Projectionists Local No. 245, I. A. T. S. E., Lynn, Mass.

J. S. CIFRE THAD. C. BARROWS
JOSEPH ROSEN H. S. DILL MAURICE ROTTENBERG

ENTERTAINMENT AND AMUSEMENTS

J. S. CIFRE A. C. HARDY C. A. B. HALVORSON
L. T. TROLAND THAD. C. BARROWS DONALD MCRAE

PRESS AND PUBLICITY

W. WHITMORE, *Chairman*

MEMBERSHIP

H. T. COWLING, *Chairman*

The Publicity and Membership Committees will have their headquarters at the entrance to the Ballroom, where the meetings are to be held.

TRANSPORTATION, BULLETINS, AND RESERVATIONS

W. C. KUNZMANN W. C. HUBBARD M. W. PALMER

OFFICIAL CINEMATOGRAPHER

H. T. COWLING

All technical sessions and film entertainments will be held in the Ballroom of the New Ocean House.

REGISTRATION HEADQUARTERS

Entrance to the Ballroom, New Ocean House

LADIES HEADQUARTERS

To be assigned later by the hotel management

NEW APPARATUS EXHIBIT

Colonial Room, New Ocean House

Chairman exhibit committee, H. GRIFFIN

Those who desire to exhibit new equipment developed within the past year, kindly communicate with the Editor-Manager of the Society at 33 West 42nd Street, New York, N. Y., in regard to exhibit regulations. Space is furnished *gratis* to the exhibitor.

HOTEL ACCOMMODATIONS

The best accommodations will be put at our disposal during our stay at the New Ocean House. The following special "American Plan" rates will apply for those attending the Convention:

Single room with bath	$9.00 daily per person
Single room with running water	8.00 daily per person
Double room with twin beds and bath	8.00 daily per person
Double room, twin beds and running water	7.00 daily per person
Suite, two rooms, four beds, bath	7.50 daily per person

Room reservation post-card will be mailed to members in September, together with the final arrangements bulletin.

TENTATIVE PROGRAM

MONDAY, OCTOBER 5TH

8:30 to 9:30 A.M.	Registration; Ballroom, New Ocean House.
	Convention called to order at 9:30 A.M.
	Opening addresses.
	Response by the President.
	Report of the Convention Committee.
	Annual report of the Secretary.
	Annual report of the Treasurer.
	Election of officers.
	Committee reports.
	Papers program.
1:00 to 2:30 P.M.	Luncheon.
2:30 P.M.	Papers program.
7:30 P.M.	Social gathering of members and guests in the Ballroom.
	Film program of unusual interest.

TUESDAY, OCTOBER 6TH

9:30 A.M.	Papers program.
1:00 to 2:30 P.M.	Luncheon.
2:30 P.M.	

The afternoon is left open for recreation. The New Ocean House offers tennis, golf, boating, fishing, bathing, and all the other pleasures of a leading resort. There are a number of golf courses within twenty-five minutes by automobile, including the Tedesco in Swampscott, the Colonial at Lynnfield, the Homestead at Danvers, the Salem Country Club and the North Shore Club at Salem; the U. S. M.

at Beverly, and the Unicorn at Stoneham. On its own grounds the New Ocean House has a modified course of 1,000 yards with 9 holes, and four tennis courts. A baseball diamond and a riding school are nearby.

Fishing and bathing can be enjoyed if weather permits. The bath house is located on the beach in front of the hotel with lockers and shower baths for ladies, and the gentlemen's locker room with shower baths in the hotel with a special entrance to the beach on the ground level.

The four tennis courts are under the supervision of a professional, and the 1,000-yard golf course with regulation greens and hazards is directly behind the hotel. No charge is made to registered members for the use of the courts or the golf course. Ping-pong tables and other indoor amusements are also available.

Swampscott is located in a center having many points of historical interest. Many interesting side-trips may be made to such places as Lexington, Concord, Salem, Gloucester, Marblehead, Plymouth, Cambridge, and Boston.

WEDNESDAY, OCTOBER 7TH

9:30 A.M.	Papers program.
1:00 to 2:30 P.M.	Luncheon.
2:30 P.M.	Papers program.
7:30 P.M.	Semi-annual banquet, Main Dining Room, New Ocean House, followed by dancing in the Ballroom.

THURSDAY, OCTOBER 8TH

9:30 A.M.	Papers program.
	Open Forum.
	Adjournment of the Convention.

Mr. O. M. Glunt, Chairman of the Papers Committee, reports an interesting program of papers for this meeting.

The New Ocean House is located in Swampscott, 12 miles east of Boston on the Boston and Maine Railroad, 25 minutes from Boston, and five minutes from Lynn, Mass., a near-by station. All trains on the Boston and Maine Railroad leave from the North Station, Boston.

A modern fireproof garage is located on the hotel property, with space for 300 automobiles. A special rate of $1.00 per day (24-hour parking) has been extended us for those who will motor to Swampscott.

The New Ocean House management assures us of their coöperation and every attention to make our Fall Meeting at their hotel an outstanding success.

TRANSPORTATION FACILITIES

How to Reach Swampscott by Train.—With the exception of *The Minuteman* from Chicago, trains from points south and west of Boston arrive at the South Station. Trains from points north of Boston, as well as *The Minuteman,* arrive at the North Station. It is necessary for guests arriving at the South Station to cross the city. Best methods are by taxi or elevated trains. Time, about five minutes. Elevated trains run every three minutes. Taxis always available.

All trains for Swampscott leave Boston from the North Station. Lynn, the station just preceding Swampscott on the way from Boston, is used quite generally by guests of the New Ocean House. There are 24 trains from Boston to Swampscott daily, and twice that number from Boston to Lynn. From Lynn, there is excellent taxi and trolley car service. Trolley cars marked "Swampscott," "Beach Bluff," or "Marblehead" come direct to the grounds of the New Ocean House. Taxis meet all late trains at Lynn and Swampscott.

How to Reach Swampscott by Automobile from Boston.—The following are the directions to reach the New Ocean House from Commonwealth Avenue and the Public Garden in Boston:

Turn left from Commonwealth Avenue on Arlington Street.
Turn right from Arlington Street at Beacon Street.
Turn left from Beacon Street into Charles Street.
Follow Charles Street to end, turn left.
Follow Route 1A to Lynn.
Turn right at Washington Street to Lynn Shore Drive.
Follow waterfront to New Ocean House.

Motor Coaches.—Motor coaches with individual parlor car seats are available for sightseeing purposes. The average cost for two- to four-hour trips is $2.00 to $2.50 per passenger.

Trip to Salem, stopping at all the historical points of interest, including the House of Seven Gables, Olde Witch House, Ropes Memorial, and Gallows Hill, returning by way of Marblehead, visiting points of interest there, including the original of the great painting, "Spirit of '76." Charge, $2.00 per person. Time, 3 to 4 hours.

Trip to Gloucester, by North Shore route, through Beverly,

Beverly Farms, Magnolia (including shopping district), and the fisheries in Gloucester. Charge, $2.50. Time, 4 hours.

Motor coaches are also available for Boston trains and golf courses.

Convention Committee

W. C. KUNZMANN, *Chairman*
W. C. HUBBARD
M. W. PALMER

Papers Committee

O. M. GLUNT, *Chairman*

Respectfully submitted,
Convention Committee
W. C. KUNZMANN, *Chairman*
Papers Committee
O. M. GLUNT, *Chairman*

OPEN FORUM

At a meeting of the Board of Governors at New York City on December 19, 1930, it was resolved: "That an open forum be established as a new department of the Journal, in which might be published letters and communications from members relating to material in the Journal or to other matters appertaining to the welfare of the Society, subject to the discretion of the Editor and Board of Editors."

Correspondence on the following subjects is invited:

(*a*) *Better ways of conducting the conventions.*

(*b*) *Problems for research.*

(*c*) *Problems for investigation by the various committees.*

(*d*) *Discussion of technical papers appearing in the Journal, with comments on the success or failure of their application.*

(*e*) *Description of interesting or new developments which have come to your attention during your travels, thereby giving all the members the benefit of this knowledge.*

(*f*) *Preliminary announcements of investigations and discoveries which are to be more fully reported at a later date in formal papers.*

721 Ashbury Street,
San Francisco, Calif.
July 21, 1931

MR. J. I. CRABTREE, *President*,
SOCIETY OF MOTION PICTURE ENGINEERS

DEAR MR. CRABTREE:

In the May number of the JOURNAL, a copy of which has reached me through the courtesy of your Editor, I am pleased to see a paper on non-intermittent projectors by Mr. Arthur Holman. His letter in the "Open Forum" of the May issue was of particular interest to me in that it states just what I should like to have your Society undertake in the interest of continuous projection.

It is, indeed, "difficult to conceive of any way in which the Society of Motion Picture Engineers can be more helpful to the industry it serves" than in conducting a thorough and scientific investigation of motion picture projection. If there are better methods for projecting motion pictures than those in common use, they should be made known to the industry. As it is practiced today, motion picture projection has many defects; and these defects should all be

pointed out and analyzed. Certainly no progress can possibly be made by totally ignoring the subject of the injurious nature of present-day projection.

The "belladonna effect," and the nerve and retinal fatigue, induced by the photoelectric properties of the retina, are examples of injurious defects that seriously challenge the attention of the motion picture industry. There is no longer any excuse for them. The art of projection has now reached its majority and there is no longer any need for the public to put up with the crudities and imperfections of its childhood.

The absolute subjection of the important matter of registration to the perforations, is another crudity that the technician would like to see outgrown. In recording and reproducing sound he has become very familiar with the advantages of a uniform motion of the film, and has learned how to obtain it quite independently of the perforations. He then very naturally longs for the time when the registration of the successive images on the screen will likewise be made to depend upon this much more accurate and scientific principle, for he instinctively knows that it will introduce a new era in the history of cinematography.

The Society of Motion Picture Engineers can perform no greater service for the industry and for the public than by actively coöperating with those who vainly have been struggling to bring on this period of growth and progress in the art. I do not know how long others have been in the struggle, but I can assure you that for ten years I have consistently endeavored to interest the motion picture industry in the many and important advantages of continuous projection, and consider it a hopeless task without the coöperation of the Society of Motion Picture Engineers or the industry.

Sincerely yours,

WM. C. PLANK

SUSTAINING MEMBERS

Agfa Ansco Corporation
Bausch & Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Carrier Engineering Corp.
Case Research Laboratory
Du Pont-Pathé Film Manufacturing Corp.
Eastman Kodak Co.
Electrical Research Products, Inc.
General Theaters Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Paramount Publix Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

	No.	Price
1917	3	$0.25
	4	0.25
1918	7	0.25
1920	10	1.00
	11	1.00
1921	12	1.00
	13	1.00
1922	14	1.00
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1923	16	2.00
	17	2.00
1924	18	$2.00
	19	1.25
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1925	21	1.25
	22	1.25
	23	1.25
	24	1.25
1926	25	1.25
	26	1.25
	27	1.25
	28	1.25
1927	29	$1.25
	30	1.25
	31	1.25
	32	1.25
1928	33	2.50
	34	2.50
	35	2.50
	36	2.50
1929	37	3.00
	38	3.00

Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N. Y., and should be accompanied by check or money-order.

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVII | OCTOBER, 1931 | Number 4

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JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

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General and Editorial Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members, $12.00 per annum; to members, $9.00 per annum, included in their annual membership dues; single copies, $1.50. A discount on subscriptions or single copies of 15 per cent is allowed to accredited agencies. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

PHOTOGRAPHIC SENSITOMETRY, PART I*

LOYD A. JONES**

Due to its length, Mr. Jones' paper on sensitometry which was presented in part on three consecutive days at the Spring, 1931, Meeting of the Society at Hollywood, Calif., will likewise be published in the JOURNAL *in three consecutive issues. The following is the first of the three installments. The paper deals in a tutorial manner with the general subject of sensitometry, its theory and practice.*

OUTLINE

I. Introduction.
- (*A*) Definition.
- (*B*) Scope of field.
- (*C*) Applications.
- (*D*) The characteristic *D*-log *E* curve.

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  - (1) *Historical résumé.*
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    - (*b*) Activated phosphorescent plate.
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    - (*b*) The complete radiator.
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  - (4) *The international unit of photographic intensity.*
- (*B*) Exposure modulators.
  - (1) *Intensity scale instruments.*
    - (*a*) Step tablets (*I* variable by finite increments).

---

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Kodak Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

(*b*) Wedge tablets (*I* variable by infinitesimal increments).
(*c*) Luther's crossed wedge tablet.
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I. INTRODUCTION

The word *sensitometry* in its broadest sense must be defined as the measurement of sensitivity and may be applied in fields other than photography. For instance, the term *visual sensitometry* is quite commonly used in referring to the science of measuring quantitatively the various responses of the human eye to radiant energy. The term *photographic sensitometry* may therefore be defined as the science of measuring the sensitivity of photographic materials. This definition, however, is purely formal and as a matter of fact does not embrace many things commonly included within the usual meaning of the term. In the broader sense photographic sensitometry includes not only the measurement of the *sensitivity* of photographic materials, but also the quantitative measurement of all of the various characteristic responses of a photographic material to radiant energy. Since this response is made manifest only by the development of the latent image formed by the action of radiant energy, the quantitative study of the action of developers in converting the latent into a visible image and the subsequent modification of that image by reducers, intensifiers, *etc.*, is also generally included in the present accepted meaning of the term *photographic sensitometry*.

Sensitometric methods and data are applied in many fields. They are used extensively by the manufacturer of photographic materials in the control of the product and in experimental work leading to the development of new products. Sensitometric methods are of great importance in research work upon the fundamental theory of the photographic process. Photographic photometry, that is, the measurement of the intensity of radiant energy by photographic methods, is based almost entirely on high-precision sensitometric measurements. In the practical application of photographic materials it is possible by sensitometric methods completely to predetermine the values of correct exposure, development, printing, *etc.*, which must be used in order to obtain photographic results of the highest quality. The theory of tone reproduction is based almost entirely upon the sensitometric determination of the response of photographic materials to light, and it is only through the application of sensitometric methods that we can determine how precisely a photograph reproduces the brightness distribution existing in the object photographed. The application of photo-

graphic materials and methods to numberless scientific problems involves the use of sensitometric data.

Until rather recently the knowledge and appreciation of the value of sensitometry and its applications have been confined largely to the manufacturers of photographic materials, to those engaged in research work in the field of photography, and to scientific laboratories where photographic materials are used as a means of making quantitative measurements. The last few years, however, have seen an enormous increase in the interest of the consumers of photographic materials, especially those engaged in the motion picture

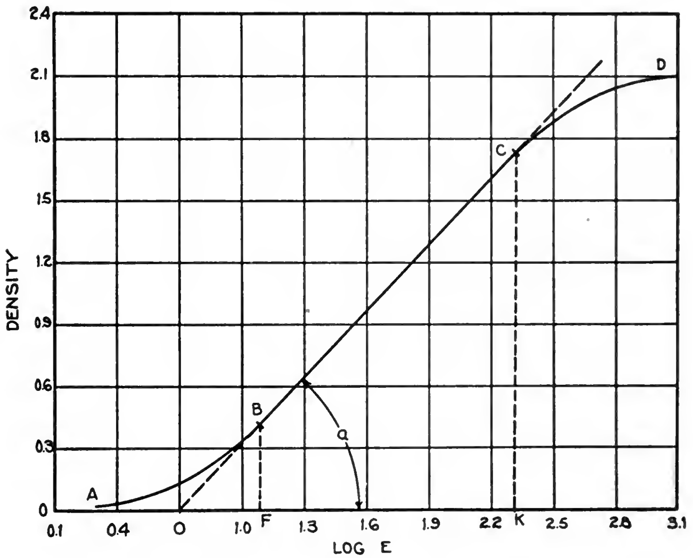

FIG. 1. Typical D-log E curve of a photographic material.

industry, in the application of sensitometric methods to the control of both picture and sound record quality. There is little doubt that, as time passes, greater and greater application will be made of sensitometric methods in the actual practical use of photographic materials.

Before proceeding with a detailed discussion of the many phases of photographic sensitometry it may be well to consider briefly the relationship between exposure and the resultant density produced by the development of the exposed photographic material. If the density of the developed image be measured and plotted as a function

of the logarithm of the exposure, a curve similar to that shown in Fig. 1 will be obtained. An appreciable portion of this D-log E characteristic curve is (within the limits of experimental measurement), for most photographic materials, a straight line which, in the case shown in Fig. 1, extends from B to C. This region is known as the region of *correct exposure,* because here the density is directly proportional to the logarithm of the exposure, and the brightness values rendered on this portion of the curve are directly proportional to the corresponding brightness values in the object. On the lower portion of the curve, A to B, this direct proportionality does not exist; this region is referred to as the *under-exposure region*, or "toe." Likewise, on the upper portion of the curve, C to D, the direct proportionality between density and exposure is not maintained, and this region is commonly referred to as the *over-exposure region* or "shoulder" of the curve.

Probably the simplest method of measuring the sensitivity of a photographic material is to subject the material in question to a series of graduated exposures (the graduation may be either continuous or discontinuous) and then to determine by *inspection* the least exposure which will produce (after development under standardized conditions) a just visible image or silver deposit. Even this simple procedure involves the establishment of four standardized or fixed conditions:

(1) A light source emitting radiation of known intensity and spectral composition.
(2) Means of producing graded exposures of known relative values.
(3) Standardized development conditions.
(4a) A method of judging the "just perceptible" developed density under standardized and reproducible conditions.

This method gives a value only for sensitivity and does not afford information as to the many other characteristics about which information is desired. Such procedure therefore fails to fulfill the needs of a completely developed science of sensitometry. In addition to the steps mentioned above it is necessary to add at least two others in order to round out the requirements of an adequate system of sensitometry. These are:

(4) A method of measuring quantitatively the magnitude of the developed image.
(5) A method of interpreting the results, either in the form of curves, numerical constants, or other suitable methods of expression.

Substituting, therefore, item 4, the precise quantitative measurement of the developed image, for item 4*a*, an estimate subject to considerable probability of personal error, it will be seen that the sensitometry of photographic material involves five distinct steps, each of which must be standardized, precisely reproducible, and designed to produce results of maximum utility for application to practical problems.

II. SENSITOMETERS

Instruments for impressing upon a photographic material a series of precisely known and graduated exposures are called *sensitometers*, and it is by means of such instruments that the requirements in items (1) and (2), referred to above as necessary steps in any system of sensitometry, are met. Since it is of such vital importance

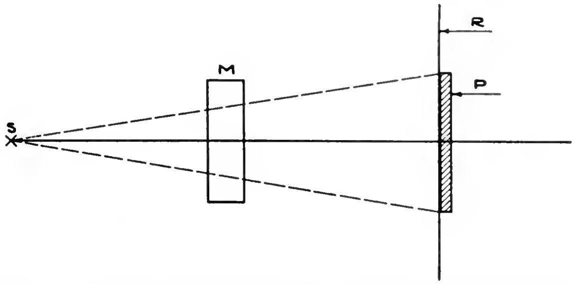

FIG. 2. Essential elements of a photographic sensitometer.

that high precision and reproducibility be obtained in exposing the photographic materials for the purposes of sensitometry, considerable time will be devoted to a discussion of various forms of sensitometers that have been used and are at the present time being used. An attempt will be made to point out at least some of the merits and faults of various types.

The essential elements of a photographic sensitometer are shown in Fig. 2, which represents a schematically generalized diagram. A light source of known *luminous intensity* and emitting radiation of known *spectral composition* is represented by S. This is placed at a distance, d, from the exposure plane, R. The surface of the photographic material, P, to be tested is made to coincide with this exposure plane, being held therein by some convenient arrangement. Between the exposure plane and the light source is located an exposure modulating device, M. The effective size of the light source

and the distance, d, are usually so chosen that the illumination, I, incident upon the exposure plane can be computed by means of the inverse square law, the luminous intensity (*i.e.*, candle power) of the source being known. Moreover, the size of the photosensitive surface to be illuminated as related to the distance, d, should be such that the illumination is the same at all points on the photosensitive surface to be exposed. Under these conditions, assuming that the exposure modulating device is removed, the entire surface of the photosensitive material will be uniformly illuminated, and if the illumination originating at the light source be allowed to act for a fixed time, every point on the photosensitive surface will receive the same exposure. The function of the exposure modulator, M, is to alter this condition in such a manner that various areas of the photosensitive surface are subjected to a series of *different* exposures which can be precisely predetermined.

LIGHT SOURCES

The characteristics of the light source, especially when used for the determination of speed values, is of utmost importance. Its *luminous intensity* must be precisely known and it should be possible to maintain this at a constant value over long periods of time.

Of equal, or perhaps greater, importance is the *spectral composition* of the radiation emitted by the source. This also must be accurately known, constant, and of very definite quality, if the final results obtained are to be of practical use. The failure to appreciate the importance of using a light source emitting a *definite* and *appropriate* quality of radiation for the sensitometry of photographic materials, and the failure of workers in this field to adopt a suitable standard of spectral composition is largely responsible for many of the apparently discordant results and has rendered many such measurements of little or at least questionable value from the standpoint of practical application.

Historical Résumé.—It will be interesting and perhaps profitable to devote a little time to a consideration of the light sources that have been used in sensitometry. It is probable that the first sensitometers (prior to about 1880) used to measure the sensitivity of photographic materials, employed sunlight (or sky light) as the illuminant. This was soon abandoned, however, owing to the variability of intensity and the difficulty of control. The lack

of a satisfactory sensitometric method induced the Photographic Club (London) in 1881 to appoint a committee to consider the standardization of plate testing. This committee recommended the adoption of the sensitometer devised by L. Warnerke.[1] The sensitometer suggested by him was of the intensity-scale type (this will be discussed more fully later), the light source from which the exposure was obtained being a phosphorescent plate employing a layer of calcium sulfide. According to the specifications, this plate was first activated by burning a piece of magnesium ribbon 1 inch long at a point "close to" the surface of the phosphorescent tablet. A time of 60 seconds was then allowed to elapse and the activated plate was placed in contact with the sensitometer tablet on the other side of which was the photosensitive surface to be tested. This was allowed to remain for 60 seconds, after which the exposed material was developed. It is quite obvious that this standard light source left much to be desired from the standpoint of precision and reproducibility. The quality of radiation emitted by the phosphorescing calcium sulfide is blue-green; hence, the photographic intensity of the radiation is relatively high, especially for the plates of the ordinary blue-sensitive type. The spectral quality, however, is quite inadequate where modern materials varying widely in spectral sensitivity are to be tested.

In selecting a light source for photographic sensitometry it was quite natural that workers in this field should turn to photometry for standard light sources that had already been developed for the establishment of the unit of luminous intensity. In Great Britain a standard candle, the British Parliamentary Candle,[2,3] was defined in the Metropolitan Gas Act of 1860, and for many years was the officially accepted unit of luminous intensity. This candle was made of spermaceti wax to specified dimensions with a wick of specified material and size. Operated as a standard candle it burned 120 gm. of spermaceti per hour. Hurter and Driffield[4] adopted this unit of luminous intensity as the light source for sensitometry. The standard candle did not continue to meet the requirements as a standard of luminous intensity on account of its lack of reproducibility. The British standard candle was finally superceded (1898) by the pentane lamp devised by G. A. Vernon-Harcourt.[5] This lamp burns a mixture of pentane vapor and air in a wickless burner. In the final form which was adopted in England as an official standard for testing gas a larger form was used giving a

luminous intensity of 10 candle power. This source was used by Hurter and Driffield in their later work.

In Germany the Hefner lamp which was invented in 1884 by F. von Hefner Alteneck[6] was adopted as the official unit of luminous intensity and is still the official standard in that country. This lamp, the prototype of which is maintained by the Physikalische Reichsanstalt, burns pure amyl acetate. In Germany, Scheiner and his followers adopted this light source for use in photographic sensitometry and it is used to a certain extent even at the present time.

In 1895 Voille[7] proposed the use of an acetylene flame as a standard of luminous intensity, and this was employed by Sheppard and Mees[8] in their investigation of the theory of the photographic process. The first burners used gave a flat (fish-tail) flame and in front of this was placed a shield with a square opening, thus allowing light from only a small portion of the brightest and most uniform part of the flame to emerge. This light source did not prove satisfactory since it was very sensitive to air drafts and to the pressure of gas supplied to the burner. Sheppard and Mees[9] therefore adopted a different type of acetylene burner, one giving a cylindrical flame similar to that suggested by Fèry.[10] The brightness of this flame varies somewhat from top to bottom but there is a considerable portion, approximately half-way between the tip and the base of the flame, where the luminous intensity per unit area is very constant. By placing a screen or diaphragm very close to the flame itself a section can be isolated which serves as a fairly satisfactory standard light source. The characteristics of this light were investigated by Jones[11] who found that by setting the window at the proper height above the burner tip and by operating the flame at a pressure of 9 cm. of water, its sensitivity to changes in gas pressure is very slight, being only 0.15 per cent for a change in gas pressure of 2 per cent. A cross-section through this burner with its protecting hood and the re-entrant window for the isolation of the most satisfactory part of the flame is shown in Fig. 3. Much experience has shown that this burner, when properly operated, is sufficiently precise and reliable for purposes of photographic sensitometry. It is not a reproducible standard and hence must be calibrated by comparison with certified standards of candle power obtained from standardizing laboratories, such as the Bureau of Standards or the National Physical Laboratory. It has one great advantage over standardized electric incandescent lamps in that the equipment required for the operation

of the source under controlled conditions is very simple, consisting only of a water manometer and needle valve, by means of which the gas pressure can be maintained at 9.0 cm. of water. The acetylene gas supplied to the burner must of course be carefully purified and freed of water vapor. Experience has shown that generators in which the calcium carbide is added to the water are more satisfactory than those in which the water is added to the carbide. This is due probably to the fact that in the former case the gas is generated at a lower temperature than in generators of the second type and hence the admixture of impurities is somewhat less. Another great advantage of the acetylene flame is the fact that under the controlled conditions specified above it emits light of constant spectral composition. It is only necessary, therefore, to standardize the source as to its luminous intensity.

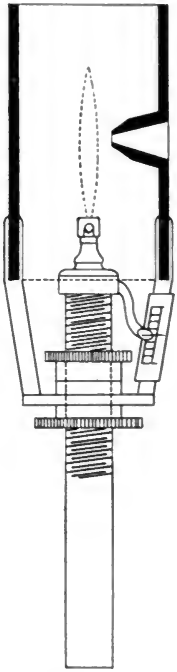

FIG. 3. E. K. standard acetylene burner.

For various reasons all the flame standards thus far mentioned have been found unsatisfactory as a means of maintaining with *high precision* the unit of *luminous intensity*. As a result of international agreement[12] (in 1909) between the standardizing laboratories of Great Britain, France, and the United States, the unit of luminous intensity which is called the *international candle* is now maintained by a group of carefully standardized incandescent electric lamps. These lamps, of course, are not primary standards of luminous intensity since they are not reproducible to specifications and none of these lamps actually have a candle power of 1 international candle. In effect, therefore, the present unit of luminous intensity, the international candle, is a unit of arbitrarily chosen magnitude (equivalent approximately to the discarded British standard candle) which is maintained by means of these carefully preserved groups of standardized incandescent lamps. Germany and other countries which had adopted the Hefner standard continued to use that unit. It has been agreed, however, to take the value of its luminous intensity as exactly 0.9 of the international candle.

It is probable that where the highest precision is required carefully standardized electric incandescent lamps are superior to any

other form of illumination for sensitometric work. In order to achieve the required precision both as to luminous intensity and spectral composition of the emitted radiation they must, however, be operated under very carefully controlled conditions. The temperature at which an incandescent filament operates is of course dependent upon the impressed voltage. Since the quality of radiation emitted by an incandescent solid is dependent upon the temperature of that material, it follows that the spectral composition of the radiation emitted by an incandescent lamp depends upon the impressed voltage or upon the current flowing through the filament. In using incandescent lamps as standards of photographic intensity, it is necessary, therefore, that they be standardized not only as to their luminous intensity but also as to the temperature at which they operate.

While many modern incandescent tungsten lamps operate at filament temperatures as high as 3100°K., it is impossible to make satisfactory standards of luminous intensity operating at the temperature mentioned. The lamps actually used by national standardizing bureaus for the maintenance of the international candle operate at filament temperatures not much in excess of 2360°K. The effective equivalent temperature of sunlight at the earth's surface is approximately 5400°K. It is obvious, therefore, that even with standardized electric lamps it is impossible to obtain radiation even approximating in quality that of sunlight.

Spectral Composition of Radiation.—The importance of specifying the spectral composition of the radiation emitted by a source used for photographic sensitometry as well as the luminous intensity of the source has often been overlooked. It is desirable, therefore, to give this point particular emphasis and to illustrate by actual examples the profound influence which variations of spectral composition may exert upon values of sensitivity obtained by sensitometric measurements. In order to do this, it will be necessary to discuss briefly some of the fundamental principles involved.

The terms "spectral composition of radiation" and "quality of radiation" have been used frequently in the foregoing discussion, and doubtless their general meaning is well understood as referring to relative amounts of energy of different wavelengths present in the radiation. For the purposes of quantitative treatment the meanings of these terms must be precisely defined. Spectral composition of radiation can in some cases be precisely represented

by a mathematical formula, but for practical purposes it is usually more convenient and useful to express the relationship graphically. Thus, if a curve be plotted, the ordinates of which represent the amount of energy (J) emitted at the various wavelengths (λ) as indicated by the abscissa values, the function

$$J = f(\lambda)$$

is graphically represented. This curve is called the spectral emission curve of the source of radiation in question. The same idea may be extended to the graphic representation of other relationships, for instance, the relation between the transmission or reflection of selectively absorbing materials as dependent upon wavelength. Thus transmission (T) $= f(\lambda)$ gives the spectral transmission curve for a selectively transmitting absorber. Likewise, reflection (R) $= f(\lambda)$ gives the spectral reflection curve for a selectively reflecting surface.

The amount of energy emitted by a complete (black body) radiator is given by the Wien-Planck formula

$$\frac{E_\lambda}{E_m} = \left(\frac{A}{\lambda\theta}\right)^5 \left(e^{\frac{C_2}{A}} - 1\right)\left(e^{\frac{C_2}{\lambda\theta}} - 1\right)^{-1}$$

in which E_λ is the radiation at any wavelength λ, E_m is the amount of radiation emitted at the wavelength of maximum energy emission, e is the base of the natural logarithms, A and C_2 are constants, and θ is the temperature in degrees absolute.

$$A = 2890 \text{ micron degrees.}$$
$$C_2 = 14{,}350 \text{ micron degrees.}$$

The radiation emitted by all the light sources thus far discussed is due to incandescence: in the case of the flame standards this is due to the incandescence of the finely divided carbon particles in the flame, whereas in the case of the electric lamp the incandescence arises from the highly heated carbon or tungsten filament. It has been found experimentally that light from any of these sources can be matched in color with the light emitted by a complete radiator at some definite temperature commonly referred to as the *color temperature* of the source. The term "color temperature," as defined by Forsythe,[13] is as follows:

> "The color temperature of a particular source has been defined as the temperature of a black body which has the same distribution of energy in the visible spectrum as the source under consideration."

The term color temperature is therefore of considerable convenience in specifying the spectral composition of radiation emitted by any light source which can be matched by a black body at some temperature.

In section (A), Table I, are given the color temperatures for the various standards of luminous intensity which have at various times been used as standard sources in photographic sensitometry. The present standard of luminous intensity, the international candle, is maintained in terms of standardized carbon and tungsten lamps. It will be noted, therefore, that the color temperature at which this unit is maintained is not over 2400°K. and, as stated

TABLE I

Color Temperature Values of Photometric Standards and Practical Light Sources

(A) Standards of Luminous Intensity

Source	Color Temperature
Standard British candle	1930
Hefner	1880
Harcourt pentane	1920
Acetylene (E. K. standard)	2360
Incandescent carbon (4 w.p.c.)	2080
Incandescent tungsten (1.25 w.p.c.)	2400

(B) Practical Sources of Illumination

Source	Color Temperature
Sunlight (mean noon)	5400
Skylight	*12000 to 18000
Crater of carbon arc (ordinary hard cord)	4000
White flame carbon arc	5000
High intensity carbon arc (sun arc)	5500
Incandescent tungsten, 10.0 lumens/watt	2500
Incandescent tungsten, 20.3 lumens/watt	2985
Incandescent tungsten, 24.2 lumens/watt	3175
Incandescent tungsten, 27.3 lumens/watt	3220

previously, it is not possible to make standard lamps of satisfactory precision and life characteristics at filament temperatures much above 2500 degrees. In section (B) of Table I are shown color temperatures of various sources which are used in practical photography. It will be noted that these are all very much higher than that which can be attained in satisfactory standards of luminous intensity.

In Fig. 4 are shown three curves representing the spectral distribution of energy in the radiation emitted by a black body at 2360°K., 2800°K., and 3200°K. It will be noted that as the temperature

* as per letter from Editor of Jr of Soc. Mo. Pic. Engrs. 12-22-

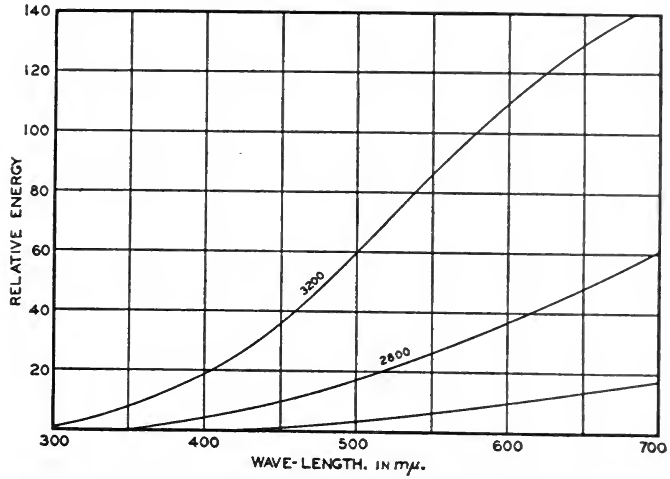

FIG. 4. Spectral distribution of energy in the radiation emitted by a black body at 2360°K., 2800°K., and 3200°K.

increases the energy emitted at all wavelengths increases but this increase is much greater proportionately in the region of longer wavelengths.

The basic reason why it is so important that the spectral composition of the radiation emitted by any source which is to be used as a standard of photographic intensity shall be *known* and *appropriate*

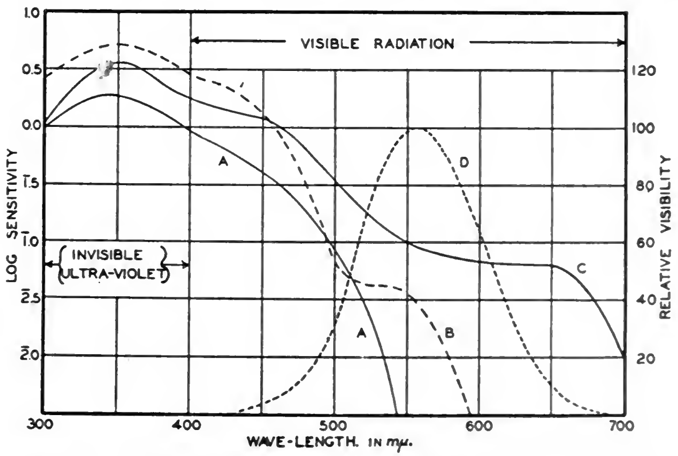

FIG. 5. Spectral sensitivity curves for three typical photographic materials: (*A*) ordinary or blue-sensitive; (*B*) orthochromatic, blue- and green-sensitive; and (*C*) panchromatic.

lies in the fact that photographic materials do not have the same. spectral sensitivity as does the retina of the human eye, which is used in the evaluation of the luminous intensity of any light source. Moreover, photographic materials differ enormously among themselves with respect to their spectral sensitivities. This is illustrated in Fig. 5, which shows the spectral sensitivity curves of three typical photographic materials, namely: *A*, ordinary or blue-sensitive materials; *B*, orthochromatic, blue- and green-sensitive materials; and *C*, a panchromatic material. The curve *D* is the spectral sensitivity curve of the average normal human eye, this

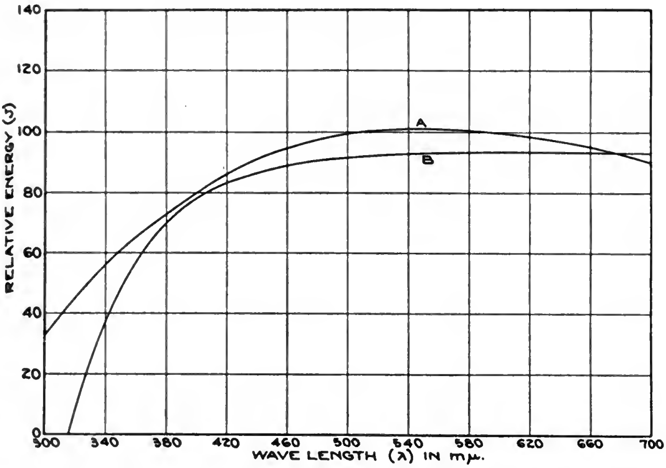

FIG. 6. Curve *A*, distribution of energy of radiation emitted by a black body at 5400°K.; curve *B*, spectral transmission for a well-known photographic objective.

curve being frequently referred to as representing the *visibility* of radiation, or the *visibility curve.* The ordinates of this visibility function are directly proportional to the magnitude of the sensation produced by the action of equal quantities of radiant energies of the wavelengths indicated on the abscissa scale. Likewise, the ordinates of the photographic spectral sensitivity curves *A*, *B*, and *C* are proportional to the response of the respective materials to equal exposures (expressed in ergs per unit area) of the wavelengths indicated on the abscissa scale. In Fig. 6, curve *A* shows the distribution of energy of the radiation emitted by a black body at 5400°K., this being the color temperature of sunlight at the earth's surface

as determined by measurements made at Washington, D. C., and averaged over a considerable period of time.

In considering the effective response of a photographic material to radiation of any specified quality, it must be recognized that in general a lens is used for the formation of an image on the material, and since this lens absorbs much of the ultra-violet radiation (*i. e.*, wavelengths less than 400 mμ) it is necessary to determine the composition of the radiation actually incident upon the plate by applying to the spectral emission curve a correction for the absorption due to the glass of the lens. Curve *B* in Fig. 6 is a spectral transmission

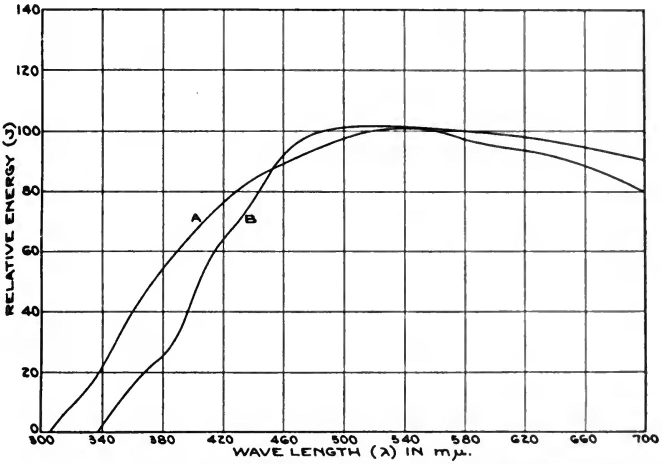

FIG. 7. Curve *A*, spectral composition of radiation actually incident on a plate if exposed through a glass lens to black body radiation of temperature 5400°K.; curve *B*, same, using solar radiation incident at the earth's surface.

curve for a well-known photographic objective, the ordinates representing transmission for the wavelengths indicated on the abscissa scale. In Fig. 7 the curve *A* is that obtained by multiplying together, at each wavelength, the ordinates of curves *A* and *B* shown in Fig. 6. This, therefore, represents the spectral composition of the radiation actually incident on a plate if exposed through a lens to black body radiation of temperature 5400°. Curve *B* is derived similarly but using, instead of the black body radiation at 5400°, the actually measured spectral composition of the solar radiation incident at the earth's surface. It will be seen that the two curves are very similar in shape, although owing to atmospheric absorption

there is somewhat less extreme violet and near ultra-violet present in noon sunlight at the earth's surface than in the radiation from the black body at 5400°, which is the color temperature of mean noon sunlight at Washington.

It is possible to compute the relative luminous and photographic intensities of any light source provided the required data are available. These are: (*a*) the spectral distribution of energy (J) in the radiation emitted by the light source; (*b*) the retinal sensitivity to radiation of various wavelengths, that is, visibility (V); and (*c*) the spectral sensitivity, that is, the photibility (M),[14] of the

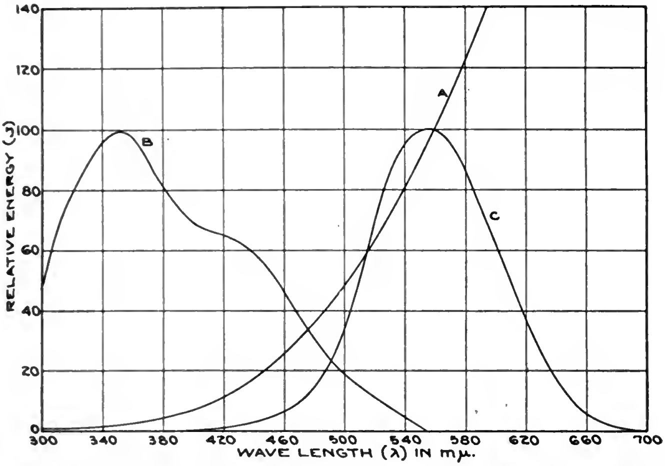

FIG. 8. Curve A, spectral emission curve for a black body at 2360°K.; B, spectral sensitivity curve for ordinary blue-sensitive photographic material; C, visibility function for the average normal human eye.

photographic material in terms of which the evaluation of photographic intensity is to be made. Since this question of the quality of radiation to be used in sensitometry is of such vital importance it will be of value to illustrate in some detail the results obtained by using light sources widely different in spectral emission.

In Fig. 8 curve A is the spectral emission curve of a black body at 2360°K. This is practically identical to the distribution in the radiation emitted by a tungsten lamp operating at a color temperature of 2360°K. and also to that emitted by the standard acetylene burner previously mentioned. Curve C is the visibility function of the average normal human eye and curve B is the spectral sensi-

tivity curve of an ordinary blue-sensitive photographic material. The luminous intensity of this source may be found by computing the luminosity curve, which is obtained by multiplying, wavelength by wavelength, the ordinates of curves A and C, and then integrating the resultant curve.

$$\text{Luminosity } (L) = \int_{\lambda=\infty}^{\lambda=0} J_\lambda \cdot V_\lambda d\lambda$$

$$J_\lambda = \text{Energy emitted at wavelength } \lambda$$

$$V_\lambda = \text{Visibility at wavelength } \lambda$$

This luminosity function is shown in Fig. 9 as curve B; the area

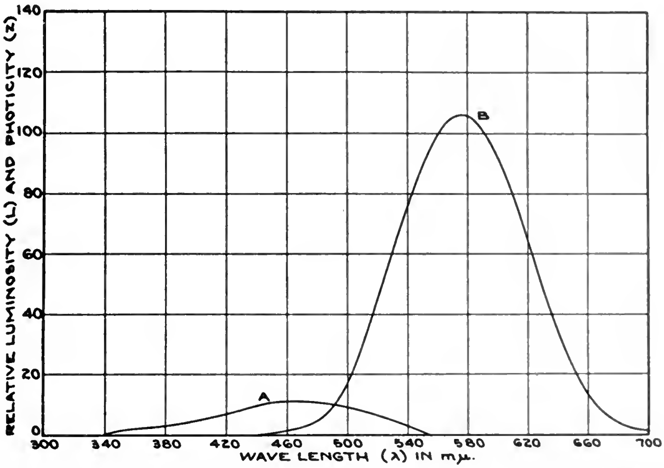

FIG. 9. Relative luminosity (A) and photicity (B) curves computed from data in Fig. 8.

enclosed by this curve is directly proportional to the luminous intensity. Likewise, the analogous function for the photographic material, which may conveniently be referred to as the photicity function, may be obtained by multiplying, wavelength by wavelength, the ordinates of curves A and B (Fig. 8) and then integrating.

$$\text{Photicity } (P) = \int_{\lambda=\infty}^{\lambda=0} J_\lambda M_\lambda d\lambda$$

$$M_\lambda = \text{Photobility at wavelength } \lambda$$

This is shown as curve A in Fig. 9. The area under this curve is directly proportional to the photographic intensity of the light source in question.

The relative areas enclosed by these two curves are expressed by curve B, 100; curve A, 12.

Likewise, by using the energy distribution of average noon sunlight at the earth's surface as shown by curve A in Fig. 10, relative values for the visual and photographic intensities for this source are obtained. The luminosity and photicity curves resulting are shown in Fig. 11, the relative areas being in the ratio curve B, 100; curve A, 50.

The speed (sensitivity) of a photographic material is expressed in terms of the exposure which will produce some definite response (a just visible density and inertia value or the like). Exposure is expressed in terms of illumination units, this being a quantity

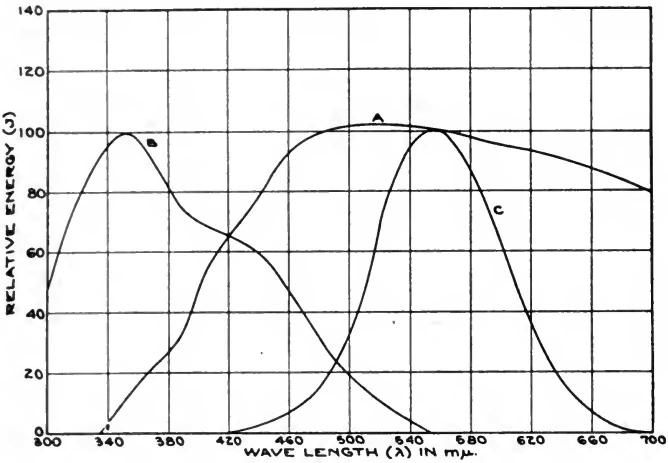

FIG. 10. Curve A, the energy distribution in average noon sunlight on the earth's surface; curves B and C, same as in Fig. 8.

measured visually. The requirement that the exposure resulting from the use of two different light sources is satisfied, therefore, by stating that the areas enclosed by the luminosity curves of the two sources in question shall be equal, assuming of course that the time factor of exposure is kept the same in the two cases. This equality of exposure has already been implied by stating that the relative areas enclosed by the luminosity curves, B in Fig. 9 (for mean noon sunlight) and B in Fig. 11 (for incandescent tungsten at 2360°), are each 100 units. It follows, therefore, since the photicity curve A in Fig. 11 has four times the area of the photocity curve A in Fig. 9, that this photographic material will have a speed

four times as great when tested with a source of mean noon sunlight quality as when tested with a 2360° tungsten standard. Actual measurements made with a 5000° source and a 2360° source show that the speed ratio is slightly less than four as indicated by these computations, the agreement between computed and the observed ratio being very satisfactory. In Table II are shown relative speed values as determined with a 2360° source and a 5000° source for the three materials differing in color sensitivity. The ratios of the speed values are shown in column F.

The spectral sensitivity of different materials classed ordinarily as blue-sensitive (that is, non-color-sensitized) varies sufficiently

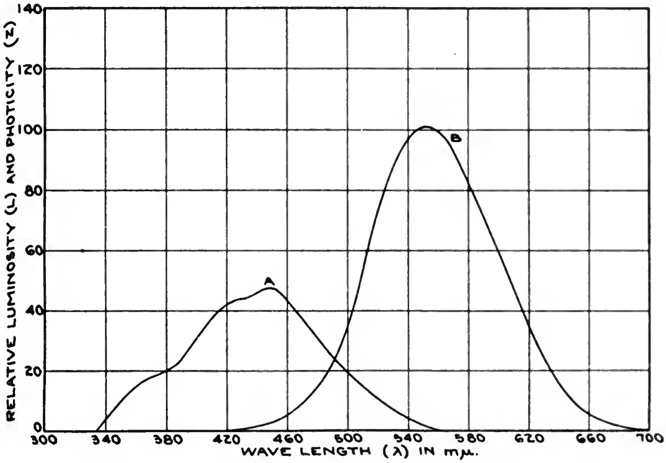

FIG. 11. Relative luminosity (B) and photicity (A) curves computed from data in Fig. 10.

TABLE II

The Effect of Color Temperature of Standard Sources upon Speed Values for Various Photographic Materials

Materials	*Color Temp. of Source* 5000°K.		2360°K.			F
	$1/i$	RS	$1/i$	RS	$\Delta RS(\%)$	
Ordinary	63	100	18	100	00	3.5
Orthochromatic	42	67	17	94	+40	2.5
Panchromatic	33	52	17	94	+81	1.9

to cause serious differences in speed when measurements are made with sources of low and high color temperature. This is illustrated

in Table III. In deciding upon a standard for use in sensitometry, therefore, an attempt should be made to choose one of such a quality that the values of sensitivity obtained shall be most useful for the purpose for which the work is being done. While undoubtedly a large amount of photographic material is at the present time exposed under artificial lighting, it seems probable that a large proportion of exposures are made to light of sunlight quality. Moreover, many of the artificial sources used in studio work are of the high color temperature type, such, for instance, as the flame arcs. During recent years tungsten illumination has been used to a great extent in many motion picture studios and also in some portrait studios. In these cases the high-efficiency tungsten lamps operating

TABLE III

The Effect of Color Temperature of Standard Sources upon Speed Values for Various Photographic Materials

	Color Temp. of Source					
Material	5000°K.		2370°K.			F
	$1/i$	RS	$1/i$	RS	$\Delta RS(\%)$	
A	63	100	18	100	00	3.5
B	63	100	15	83	−17	4.2
C	50	79	18	100	+27	2.8
D	46	73	16	89	+22	2.9
E	44	70	14	78	+11	3.1
F	23	37	8	44	+19	2.9
G	10	16	4	22	+37	2.5
H	3.5	5.6	1.2	6.7	+18	2.9

at approximately 3000°K. or 3200°K. are used. A careful study of the whole situation has led to the conclusion that it is highly desirable to adopt for the sensitometry of negative materials a source of high color temperature, in fact, one duplicating as closely as possible mean noon sunlight.

Modern Standards of Intensity and Quality.—Reference to the table of color temperatures (Table I) shows that no satisfactory standard of luminous intensity is available which even remotely approaches sunlight in spectral compositon. It becomes necessary, therefore, to use a selectively absorbing filter between the light source and the exposure plane in order to obtain the desired spectral quality. For many years the cylindrical acetylene flame standard, previously mentioned, has been used in combination with a dyed gelatin filter (Wratten No. 79). The radiation from this source-

filter combination matches very closely in color that from noon sun. Spectrophotometric examination of the transmitted radiation shows that the match is only a subjective one and that there is an appreciable departure from the actual spectral distribution of radiation in mean noon sunlight. The departure, however, is not sufficiently great to be serious from the practical standpoint. In fact, speed values determined with this source-filter combination using materials differing widely in spectral sensitivity agree very well with speed values determined by using actual sunlight. The filter mentioned is very stable and while not precisely reproducible, in the sense of a primary standard, it can be manufactured to within

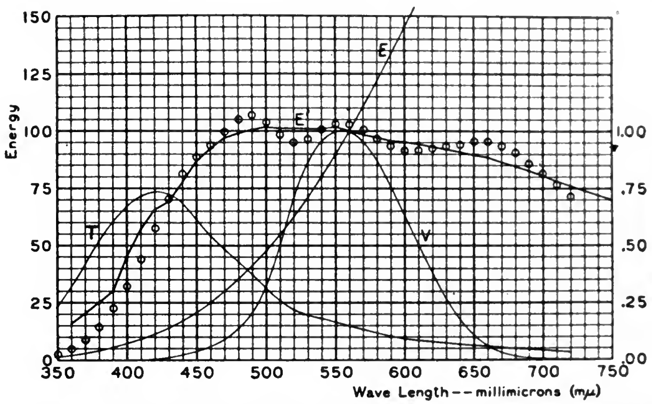

FIG. 12. Curve T, spectral transmission of Davis-Gibson filter; curve E, spectral distribution of energy for incandescent tungsten lamp at 2360°K.; curve E', energy distribution for sunlight at the earth's surface.

narrow tolerance limits and then standardized with the required precision. For this purpose the cylindrical acetylene flame referred to previously in combination with a dyed gelatin filter (Wratten No. 79) gives a very good approximation to the desired spectral quality. This filter is reproducible and stable, and hence the acetylene flame-filter combination may be considered as a very satisfactory standard source for the sensitometry of negative materials.

Blue glass filters are also available and when used with the acetylene flame, or, in fact, with a tungsten lamp operating at equivalent temperature, give a fair reproduction of mean noon sunlight. These glass filters as a rule are not especially reproducible but are very stable and after once being obtained and standardized are very

satisfactory. More recently Davis and Gibson[15] have developed a liquid filter consisting of two solutions which when combined with either acetylene or a standard tungsten lamp operating at 2360°K. duplicates mean noon sunlight very precisely. In Fig. 12, curve T shows the spectral transmission of this filter. When the filter is used with an incandescent tungsten lamp operating at a color temperature of 2360°K. (or with the E. K. standard acetylene burner), radiation is obtained of which the spectral distribution is indicated by the small circles (Fig. 12). The solid curve designated as E' represents the spectral quality of mean noon sunlight at the earth's surface. It will be seen, therefore, that the filter-source combination gives a fair approximation to radiation of sunlight quality. These filters are reproducible with high precision and have good stability. They represent, in fact, the most satisfactory means of realizing in the laboratory radiation of this quality for sensitometric purposes.

The International Unit of Photographic Intensity.—The International Congress of Photography has for some years been attempting to standardize a satisfactory unit of photographic intensity. At the seventh congress which met in London, 1928, a resolution was passed adopting a 2360° source screened with the Davis-Gibson (*loc. cit.*) liquid filter as a means of realizing the international unit of photographic intensity, which is defined as one visual candle power of radiation of the quality emitted by the source-filter combination mentioned above. The Davis-Gibson filter for use with a 2360° source is made up according to the following formula.

Solution A

Copper sulfate ($CuSO_4 \cdot 5H_2O$)	3.707 g.
Mannite ($C_6H_8(OH)_6$)	3.707 g.
Pyridine (C_5H_5N)	30.0 cc.
Water (distilled) to make	1000 cc.

Solution B

Cobalt ammonium sulfate ($CoSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$)	26.827 g.
Copper sulfate ($CuSO_4 \cdot 5H_2O$)	27.180 g.
Sulfuric acid (Sp. gr. 1.835)	10.0 cc.
Water (distilled) to make	1000 cc.

EXPOSURE MODULATORS

Referring again to Fig. 2, it will be seen that the second important element in any sensitometer is a device by means of which the exposure incident upon various areas of photographic material may be controlled. There are many ways in which this can be accomplished. Before considering the historical evolution of the sensitometer it may be well to develop a logical classification for these instruments

as a means of clearly understanding the various types which will be discussed later.

Exposure (E) is defined as the product of the illumination (I) incident upon the photosensitive surface by the time (t) during which the illumination is allowed to act. Thus:

$$E = I.t$$

It is evident, therefore, that exposure may be varied by controlling either the time (t) or the intensity (I) of exposure. Sensitometers may be classified most logically in terms of the manner in which the control of exposure is accomplished. If the illumination (I) is variable, t being constant, the resultant series of exposures is referred to as an *intensity scale.* On the other hand, if the time (t) of exposure is variable, I remaining constant, a *time scale* of exposure is obtained. One of the earliest methods of obtaining a time scale of exposures was to use a rotating disk in which were cut a number of annular slots varying in angular dimensions. This was rotated between the light source and photographic plate at a relatively high speed (200 to 600 rpm.). The exposure times usually used were relatively long, greater, let us say, than 30 seconds. It is evident, therefore, that such a device produced an illumination incident upon the photographic material consisting of a relatively large number of flashes separated by an equal number of dark periods. In other words, the illumination was *intermittent.* It was assumed that the photographic plate would integrate these successive exposures and that the result would be equivalent to an exposure of which the time factor was equivalent to the sum of the times of the numerous flashes composing it. Abney[16] found (and since that time his results have been confirmed by many other investigators) that the photographic plate does not integrate an intermittent exposure. The effect of intermittency may introduce relatively large errors in sensitometric work. A sector wheel, such as that mentioned above, may be operated in such a manner that the desired series of exposure times is obtained by a single revolution of the wheel and under these conditions the exposure is *non-intermittent.*

In both the intensity scale (type I) and the time scale (type II) instruments the variation of exposure from point to point on the sensitive material may be *continuous* or *discontinuous,* thus giving after development a silver deposit which shows a continouous change in density, or one which consists of a series of distinct steps. For

convenience the former type of exposure will be referred to as a *wedged exposure,* whereas the latter will be designated as a *stepped exposure.* On the basis of the manner in which the exposure is modulated, the following classification of sensitometers may be made:

TYPE I: INTENSITY SCALE INSTRUMENTS.

I variable, t constant.

(1) Wedged exposure.
(2) Stepped exposure.

TYPE II: TIME SCALE INSTRUMENTS.

I constant, t variable.

(*a*) Exposure intermittent.
(1) Wedged exposure.
(2) Stepped exposure.

(*b*) Exposure non-intermittent.
(1) Wedged exposure.
(2) Stepped exposure.

Intensity Scale Instruments.—Having now considered briefly the classification of sensitometers it may be well to devote a little attention to the historical evolution of the exposure modulator. The first of these was of the intensity scale type and consisted of *tablets* constructed in various ways. These were placed in contact with the photographic material to be tested and exposed to a standard light source for a fixed time. It seems probable that the first sensitometers used in the testing of photographic plates prior to 1880 consisted of tablets made up by superposing an increasing number of layers of tissue paper in such a way that the illumination reaching the sensitive surface was controlled in an approximately known manner. These undoubtedly grew out of the so-called *actinometers* which were used, previous to the introduction of the dry plate, for measuring the photographic intensity of light sources used for the printing in such materials as the bichromated gelatin of the carbon tissue. It was customary to place opaque numbers on the various steps of these tablets and after development to determine the speed of the material by reading the faintest distinguishable number on the developed image.

The sensitometer devised by L. Warnerke (*loc. cit.*) has already been mentioned. This was of the intensity scale type giving stepped exposures, the exposure modulating element consisting of a "tablet." This tablet consisted of a glass plate approximately $3^1/_4$ by $4^1/_4$

inches, on the surface of which were located twenty-five squares increasing in density by supposedly equal increments. These squares were formed by making a cast in gelatin from an original die produced by superposing sheets of paper, the casting method used being that known in photography as the Woodbury type. The various areas were numbered consecutively by means of superposed opaque numbers. The proportion of black pigment admixed in the gelatin was supposedly so adjusted that an increase of three numbers on the tablet represented a decrease of light intensity of 50 per cent. Measurements on actual tablets, however, indicate

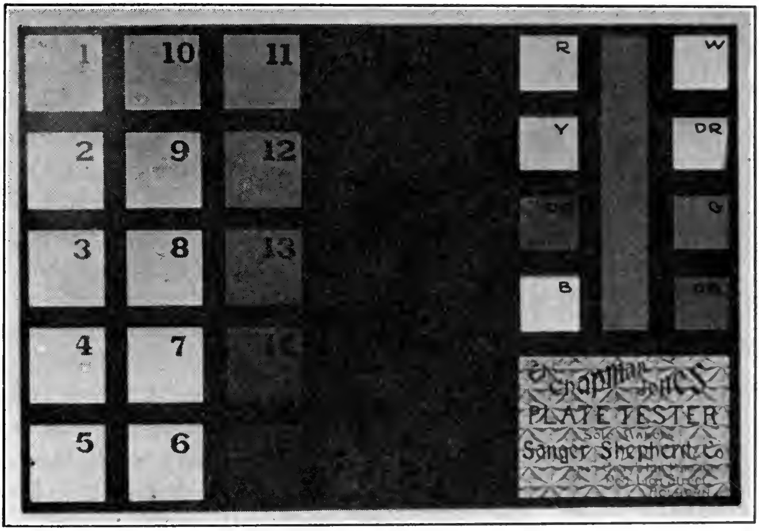

FIG. 13. Chapman-Jones sensitometer tablet.

that this ideal was not approached with anything like the desired precision. Moreover, the tablets were not precisely reproducible, nor was the gradient (that is, the density increment from step to step) accurately known.

A later revival of the Warnerke sensitometer tablet is found in the photographic plate tester suggested by Chapman-Jones.[17] This tablet was also made by casting dyed or pigmented gelatin by a process similar to that of the Woodbury type. A reproduction of this sensitometer tablet is shown in Fig. 13. The square areas on the left-hand side are neutral gray absorbers numbered from 1 to

25. In this print the number 19 is just visible, and therefore it becomes a measure of the sensitivity of the material on which the print was made. The square areas on the right-hand side are made of dyed gelatin in various colors and an inspection of these gives an approximate idea of the color sensitivity of the material. Like the Warnerke tablet the Chapman-Jones plate testers, as commercially available, are distinctly irregular. Measurements made on one of these tablets indicate a mean step increment of 0.13 in density. It seems probable that since this tablet was derived from the Warnerke it was intended to have a step increment of 0.10, in which case every third step would decrease the intensity to one-half.

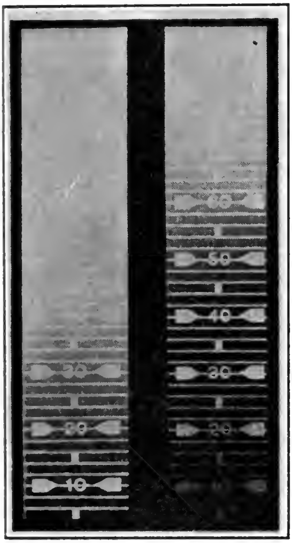

FIG. 14. Prints made from Eder-Hecht wedge type sensitometer tablet.

More recently Eder[18] has introduced a sensitometer tablet in which the gradation of density is continuous rather than in steps like the Warnerke and Chapman-Jones tablets. This is made by casting a wedge of dyed gelatin by the Goldberg process.[19] The dye used is intended to act as a non-selective absorber for all wavelengths to which the photographic material and the eye are sensitive. This desirable condition is not in all cases obtained with high precision since there is in many cases a very definite lack of visual neutrality. Lines are ruled across the tablet and are numbered so that in the print made from this tablet the speed of the material is indicated by the highest number which is visible. Superposed on this tablet are strips of colored gelatin which serve as an indication of the color sensitivity of the material. A specification of the density gradient is given for this tablet, which is 0.4 density per centimeter. Actual measurements made on some of these tablets, however, do not agree well with this value and it seems probable that each tablet should be actually calibrated if any degree of precision is to be obtained. In Fig. 14 are shown two prints made from the Eder-Hecht wedge type sensitometer tablet. In one case it will be noted that the highest number just visible is 40, whereas in the other

case it is 70. These two numbers then express the relative speeds or sensitivities of the two materials used in making the prints.

Many other types of tablet sensitometers have been made but the three already mentioned are fairly representative of the class. In general, this type of exposure modulator does not appear to be very satisfactory owing to difficulties of obtaining reproducibility, permanency, and high precision in exposure gradient. It is almost impossible to find a material which is sufficiently non-selective so that visual calibration of these tablets can be assumed to hold for photographic materials which are sensitive to an entirely different range of wavelengths than is the eye.

If tablet sensitometers must be used it appears now that the best material to use, from the standpoint of permanency and both visual and photographic neutrality, is a silver image which has been developed so as to have non-selective absorption. It must be remembered, of course, that such tablets are composed of diffusing deposits and that the values of density and the gradient must be determined in such a manner that they will apply to the conditions under which the tablet is used, such, for instance, as by contact or by projection.

A very ingenious device suggested by R. Luther[20] in 1910 consists of two neutral gray wedge tablets superposed with the axes of density gradient at right angles to each other. Each neutral gray wedge is square so that the two fit over each other giving a square sensitometer tablet which modulates the intensity of exposure in two directions at right angles to each other. When a photographic material which has been exposed behind this tablet is developed, the dense area outlines approximately the D-log E characteristic curve of the material. The density gradient of each tablet is very high, the range of transmitted illumination varying from approximately 1 to 1,000,000 for each wedge. A reproduction of a test made with Luther's crossed wedge sensitometer is shown in Fig. 15. The sensitometer certainly has some advantages where a rapid means of testing is desired. It does not seem probable, however, that sufficient precision can be obtained for standardized sensitometric work.

Another form of the type I exposure modulator is that designated as the tube sensitometer which consists of a series of tubes or cells of equal length, at one end of which is placed the photographic plate, the other ends of the various tubes being closed by opaque plates

containing apertures of variable areas. If these apertures are properly illuminated the intensity of the light acting on the photographic plate at the other end of the tubes will be directly proportional to the areas of the apertures. The chief objection to sensitometers of this type is the inability to obtain a very wide range of illumination without using tubes of excessive length and diameter, the former of necessity resulting in low intensity of illumination on the plate, and the latter in a spreading of the exposed

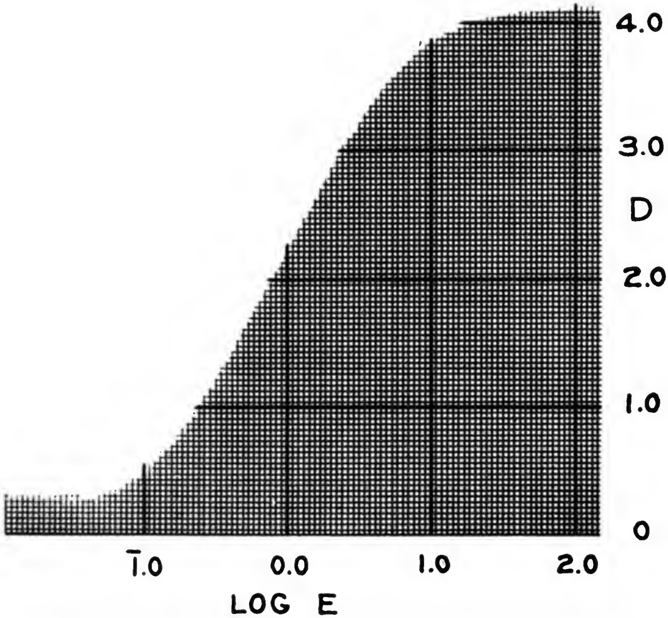

FIG. 15. Reproduction of test made with Luther's crossed wedge sensitometer.

areas over a relatively large specimen of the photographic material to be tested. In general, it is desirable that the illumination level be as nearly equal as possible to that obtaining in practice in order to eliminate errors arising from the failure of the reciprocity law. Furthermore, it is desirable to limit the area over which the variable areas are distributed as much as possible. Sensitometers of the tube type have been used by Spurge,[21] Vogel,[22] Luther,[23] and others.

Intensity scale exposures may be obtained in other ways but those already discussed represent the instruments of this type

that have been used extensively. Intensity scale sensitometers involving the use of an optical imaging system with variable diaphragms as a means of obtaining intensity scales have been proposed. In fact, one instrument of this type has been designed and constructed, and promises to be very satisfactory. These instruments are inherently rather complicated and require the highest quality of mechanical and optical workmanship, thus rendering them rather expensive to build. Variation of intensity may be accomplished either by a series of fixed diaphragms or by a continuously variable diaphragm, thus giving either a wedged exposure or a stepped exposure as desired. It is quite generally agreed that an intensity scale sensitometer represents the ideal form since in practice photographic materials are almost invariably exposed under variable intensity conditions. However, no really satisfactory sensitometer of the intensity scale type giving the required reproducibility, intensity, and precision has been commercially developed. The first photographic investigator to make quantitative measurements on the effect of exposure was Abney in 1882.[24] He used a sensitometer of the tube type known at that time as a Spurge sensitometer.

Time Scale Instruments.—We come now to a consideration of exposure modulating devices producing time scale exposures. A rotating sector wheel was proposed for this purpose as early as 1840 by Claudet and later in 1889 by Bolton.[25] It remained, however, for Hurter and Driffield[26] to actually apply the rotating sector wheel sensitometer to photographic research. These investigators laid the foundations of modern sensitometry in 1890. They constructed a sensitometer in which the exposure time modulating device consisted of a rotating sector disk, as shown in Fig. 16. In this wheel was cut a series of annular apertures decreasing in angular dimensions from the center outward, the largest angular aperture being 180 degrees, the next 90 degrees, the next 45 degrees, *etc.*, each being one-half the angular length of the preceding opening. Nine steps were cut in the sector wheel, thus giving a series of exposure times increasing logarithmically by consecutive powers of 2 covering a range of 1 to 256 exposure units. This type of sensitometer was for many years the standard instrument, and it is only within the last fifteen or twenty years that improved instruments have made their appearance. The sector wheel used in the sensitometer of Hurter and Driffield was rotated at a relatively high angular velocity (200 to 600 rpm.), thus subjecting the photographic material

to a series of intermittent flashes. This sensitometer therefore belongs to the type II(*a*) (stepped exposure), in which the intensity is constant and the time variable, the exposure being intermittent.

Using this sensitometer, Hurter and Driffield soon established a relationship between the mass of the silver deposit in the negative and the light transmitted by it. They showed that the logarithm of the reciprocal of the transparency, which they termed density, is directly proportional to the mass of silver per unit area. Unlike Abney (*loc. cit.*), who plotted his results in the form of transmission

FIG. 16. Rotating sector wheel disk of the Hurter and Driffield rotating sensitometer.

as a function of exposure, they plotted their data in the form of density as a function of the logarithm of the exposure and in this way obtained the well-known characteristic curve of the photographic material. While this curve is in the most general aspect an S-shaped curve in which there is a point of inflection at which the first derivative or gradient changes sign, it was found in practice that for many materials there is a considerable portion of the curve which, within the limits of experimental measurement, is a straight line, and for this region density is a linear function of log E. This method of graphically expressing sensitometric data was gradually

adopted and at the present time it is practically the universal custom, except in certain specialized applications of sensitometry, to express sensitometric data in the manner initiated by Hurter and Driffield. It is obvious that if it is desired to obtain experimentally determined points on this curve which are equally spaced along the log E axis, the sensitometer used should be so constructed as to give a series of exposures increasing logarithmically rather than arithmetically. The exposures should therefore be represented by the series 1, 2, 4, 8, 16, *etc.* This scale is frequently referred to as consisting of consecutive powers of 2. If, for the sake of establishing the curve with greater precision, it is desired to interpolate a point between each of the points represented by the scale mentioned above, it is

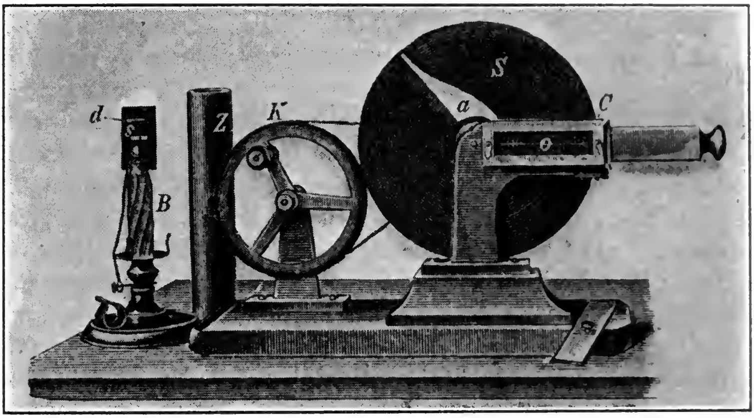

FIG. 17. Scheiner's rotating sector wheel sensitometer.

only necessary to use exposures increasing by consecutive powers of $\sqrt{2}$, namely, 1, 1.41, 2, 2.82, 4, 5.64, 8, *etc.* Furthermore, if it seems desirable, as it frequently is, especially in the case of materials having extremely short exposure scales, to interpolate two points between each of the points given by the first scale mentioned, a series of exposures given by the consecutive powers of the $\sqrt[3]{2}$, such as 1, 1.26, 1.59, 2, 2.56, 3.174, *etc.*, may be adopted.

In 1894 Professor J. Scheiner[27] described a sensitometer of the rotating sector wheel type, shown in Fig. 17, giving a continuously graded exposure (wedged exposure) instead of a stepped exposure as in the case of the Hurter and Driffield instrument. The aperture cut in this wheel instead of being cut in steps was bounded by a

continuous logarithmic curve. A scale plate was placed in position between the rotating sector and the photographic plate so that, after exposure, images of cross lines with numbers appeared in the developed image. The numbers varied from 1 to 20 and the ratio of exposure between consecutive numbers was 1 to 1.27, thus making a total exposure range of 1 to 100 between No. 1 and No. 20. Thus, a photographic material on which No. 20 could just be read would have a speed 100 times that of a material on which No. 1 was just visible. The sector wheel was driven at a relatively high angular velocity, thus giving an intermittent exposure.

Scheiner did not measure the densities on the plate but based his speed determinations on the least perceptible density, such determinations being referred to generally as *Schwellenwert* or *threshold* values.

A little later in 1899 J. M. Eder[28] developed a system of sensitometry based upon a modification of the Scheiner rotating sector wheel. Instead of using the continuous logarithmic aperture he changed this to a discontinuous or step type in which the exposure time ratio between consecutive steps was 1 to 1.27, maintaining, in fact, Scheiner's previously established speed or sensitivity scale. Eder added several other refinements, such as the introduction of color filters for obtaining data on the color sensitivity of photographic materials. The Eder-Scheiner instrument is of the II(*a*) type giving stepped exposures. The Scheiner system of speed measurement and specification is still in use in Germany at the present time, about the only changes having been made since its introduction by Scheiner and Eder being in the standard light source used. Scheiner originally used a benzene lamp but this was later changed to a standard Heffner lamp.

Sensitometers of the type II(*b*) were little used in the earlier days of sensitometry. One proposed by Cowan[29] consisted of a plate which was allowed to fall under the action of gravity. In this plate were cut a series of slots of different lengths allowing the light to act for various intervals of time upon the areas of a sensitive surface behind the falling plate. The chief objection to this type is the necessity of applying a correction to compensate for the variation in fall due to gravitational acceleration (or modifying the lengths of aperture to compensate for this factor) and also of maintaining the instrument in such adjustment as to assure the perfectly free fall of the plate at all times.

Another form proposed by General Sebert[30] is more satisfactory but does not seem to have been used extensively. It consisted of a plate holder carrying the sensitive material to be exposed driven at a constant velocity past a metal plate in which were cut slots of different lengths. Constant velocity was obtained by means of a clock-work controlled pendulum.

The rotating sector wheel type of sensitometer referred to in the previous paragraphs is a very convenient form of instrument but unfortunately it has a very serious fault, this being the intermittent character of the exposure given to the photographic plate. It has been found that the photographic surface does not in general integrate an intermittent exposure. In this respect it is distinctly different from the human eye in its reaction to radiant energy since it has been shown that the human eye very precisely integrates an intermittent exposure, the sensation produced being directly proportional to the average illumination on the retina. The intermittency effect has been investigated by Abney,[31] Englisch,[32] Schwarzschild,[33] Howe,[34] Davis,[35] Jones[36], and many others. While it is not proposed at this time to discuss at length the intermittency effect, it seems desirable to present sufficient evidence to prove definitely the desirability of abandoning the intermittent sensitometer in favor of one giving non-intermittent exposures. In Table IV are given the values

TABLE IV

The Effect of Intermittent Exposure on Speed Values

No.	Exp.	Time (Max.)	Speed	γ
		Intermittent		
1	$^1/_8\ N$	10	107.0	2.12
2	$^1/_4\ N$	20	95.5	2.19
3	$^1/_2\ N$	40	83.8	2.23
4	N	80	73.0	2.27
5	$2\ N$	160	60.8	2.25
6	$4\ N$	320	49.5	2.29
		Non-intermittent		
7	N	80	125.4	1.43

of speed obtained with intermittent exposures of various durations and with a non-intermittent exposure made at approximately the same illumination level. It will be noted that the speed value obtained on the intermittent sensitometer is a function of the time of exposure, which, of course, it should not be, since speed is expressed in

terms of reciprocal inertia into which has already been computed the exposure time. It will be seen that as the actual exposure time is increased the speed value obtained decreases. Moreover, it will be noted that with the non-intermittent exposure made at the same intensity level the speed value is somewhat higher than any of those given by the intermittent sensitometer. It has been suggested that,

TABLE V

The Effect of Intermittent Exposure on Speed Values

			Intermittent			
Time(Max.)	A	B	C	D	E	F
20	...	...	131	115	107	210
40	...	...	115	108	103	140
80	100	100	100	100	100	100
160	99	93	83	90	96	75
320	97	83	68	79	90	55
			Non-intermittent			
80	103	100	171	107	102	189

A. Very slow ordinary.
B. Very slow ordinary.
C. Medium speed panchromatic.
D. Medium speed ordinary.
E. Fast ordinary.
F. Fast ordinary.

although this intermittency effect does exist, still an intermittent type of sensitometer should be entirely satisfactory for measuring relative speeds of different materials. The data in Table V definitely show that this is not the case. Magnitude and character of the intermittency effect is different for different materials. In Fig. 18 are shown two curves made under identical conditions, one with an intermittent and the other with a non-intermittent exposure. It will be noted that the non-intermittent exposure gives a higher speed value and a somewhat lower gamma than does the intermittent exposure. The quantitative results, shown in Fig. 18 and Tables IV and V, must not be considered as being valid under all conditions. For instance, Davis (*loc. cit.*) has shown that speed values for non-intermittent exposures may be lower than for intermittent exposures, and furthermore, that the relative slopes of the curves shown in Fig. 18 may be reversed, depending upon the intensity levels at which the comparisons are made.

The errors inherent in time scale instruments of the rapidly rotating sector wheel type caused by the well established intermittency effect, have led to the development of several types in which this objectionable feature is avoided. In Fig. 19 is shown a form of falling plate instrument,[36] in which the slotted plate carrying a series of apertures varying logarithmically in length is guided by vertical ways and is driven at a uniform linear velocity by means of a motor-driven chronograph mounted on the base of the instrument. The motor used is of the governed type, thus giving a relatively high precision timing.

A slightly different form is shown in Fig. 20. In this case an

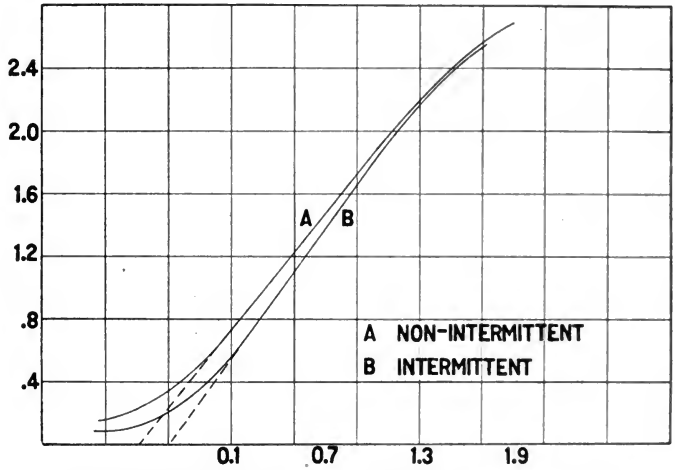

FIG. 18. *D*-log *E* curves derived from intermittent and non-intermittent exposures of identical magnitudes.

opaque plate is allowed to drop at predetermined time intervals in front of the photosensitive surface thus cutting off the illumination incident on various areas at a series of times so calculated as to result in the desired time scale of exposure. The dropping of the opaque shutter plate is controlled by a solenoid actuated by means of the contact maker shown at the lower right-hand part of the figure. This circuit-making device consists essentially of a strip of motion picture film in which are perforations spaced logarithmically as shown in Fig. 21. This is driven at a constant linear velocity by means of a synchronous motor through a film gate provided with a contact-making device so that as each aperture comes into position

an electrical contact is made, thus allowing the shutter plate to drop one step and cut off the illumination from one portion of the photosensitive material. The off-set aperture, as shown at *G* in Fig. 21, operates a second contacting device which turns on the light source at the proper instant.

As mentioned previously, a non-intermittent, time scale exposure

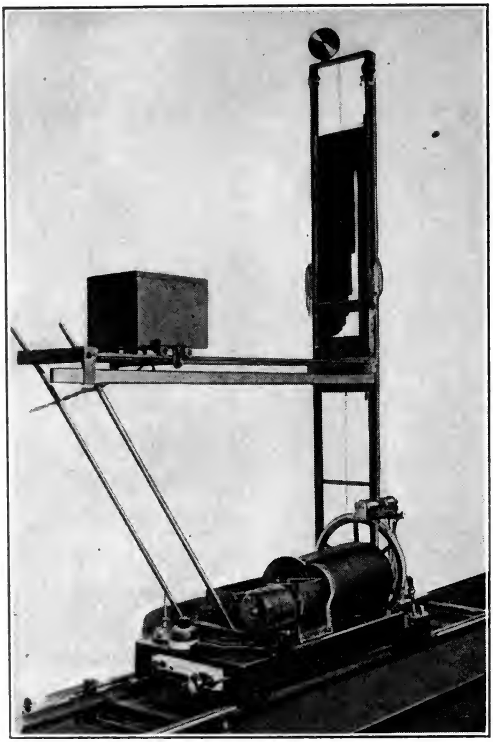

FIG. 19. Non-intermittent sensitometer using a slotted shutter moving at constant velocity.

can be obtained by a sector wheel identical in design to that used by Hurter and Driffield. It is only necessary to drive the disk at the proper angular velocity so that the required times of exposure are obtained by a single revolution of the wheel. The opaque portion of the disk may serve to protect the sensitive material while it is being placed in position in the exposure plane. The disk may then be picked up by means of a suitable clutch connecting it to a driving

mechanism which is operating continuously at a constant angular velocity, the clutch automatically being disengaged after the disk has made one revolution, thus stopping in a position so that the opaque portion of the disk again acts as a shutter for protecting the sensitive material from illumination. This mode of operation is only feasible when the time for a complete revolution of the disk is relatively long, since it is not advisable to start the disk at a high angular velocity and again stop it at the end of the exposure cycle. Where it

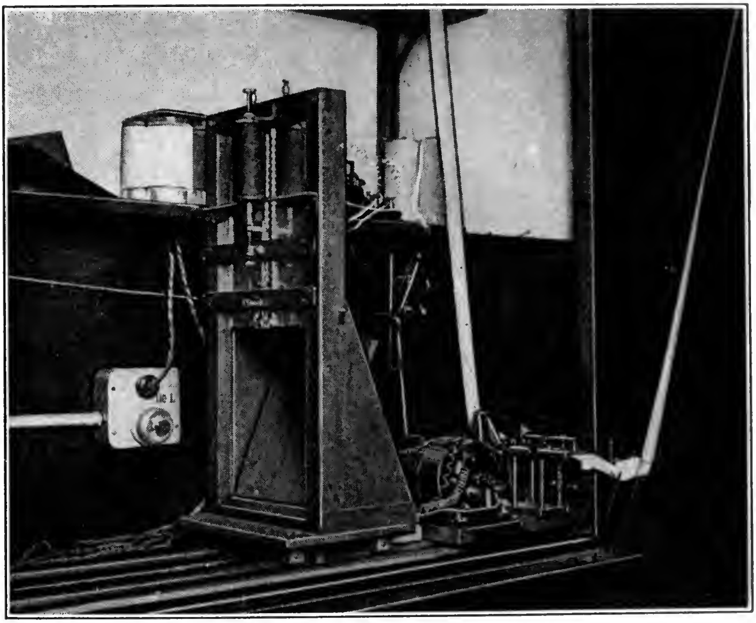

FIG. 20. Non-intermittent sensitometer using a shutter plate moving discontinuously at logarithmic time intervals.

is desirable to use a series of exposure times which are relatively short, the better plan is to allow the sector disk to operate continuously at a fixed and relatively high angular velocity and then to use a selector shutter operated in synchronism with the sector disk so that the photographic material is subjected to illumination resulting from one cycle of the disk. Various sensitometers based on these general principles have been made. One such instrument is shown in Fig. 22. The sector wheel is mounted in the housing, D, the standard light source in the housing, H, and the sensitive material is held in the

exposure plane by means of the plate holder, *E*. The driving mechanism which consists of a synchronous motor is mounted on the base at the extreme left and a one-turn mechanism serves to pick up the sector disk and carry it through exactly one complete revolution. For a more complete discussion of the instrument those interested are referred to the original article.

A sensitometer of similar design has been described by Hardy[37] in which the exposure time scale is extended to much shorter times by the use of a one-sectored disk mounted on a shaft concentrically located with respect to the one driving a second disk at a lower angular velocity. A slot of relatively small angular dimensions in the larger and slower moving disk serves as a selector shutter, thus isolating the exposures due to a single revolution of the faster moving

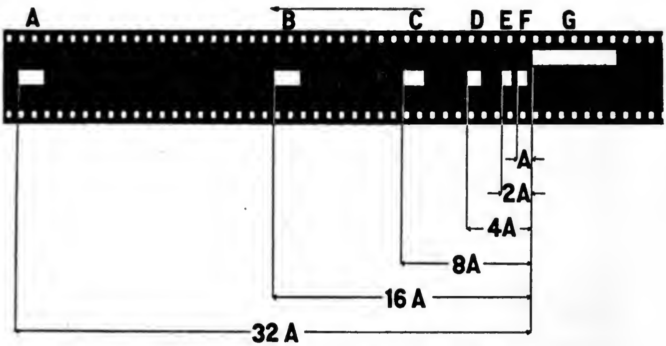

FIG. 21. Perforated tape used for actuating the sensitometer shown in Fig. 20.

disk which operates at an angular speed thirty-two times as great as that of the other. The more slowly moving disk is picked up by a suitable clutch mechanism which causes it to make exactly one revolution. This sensitometer gives a time scale consisting of thirteen steps varying in exposure time by consecutive powers of 2.

A sensitometer of the one-turn sector wheel type has also been constructed and used at the Bureau of Standards.[38] This is a very elaborate machine designed to work over a wide range of exposure times. In this instrument the sector wheel runs continuously at a predetermined speed calculated to give the desired exposure times depending upon the sensitivity of the material being tested. The exposure intervals due to a single revolution of the wheel are automatically isolated by an electromagnetic selector shutter which is

operated by means of a commutator attached to the shaft on which is mounted the exposure time modulating shutter.

A double sector wheel sensitometer[39] similar in design to the Hardy instrument (*loc. cit.*) is shown in Fig. 23. This, as will be seen, consists of two concentrically mounted sector wheels, the large one rotating at a lower angular velocity ($^1/_{16}$) than the smaller, inner disk. The larger disk contains a narrow aperture which serves as an automatic selecting shutter for isolating the exposures due to the inner high-speed disk. In the design of this instrument particular attention was devoted to obtaining a high level of illumination on the sensitive material such that the exposure times could be made very short and at the same time obtain sufficient exposure for the testing

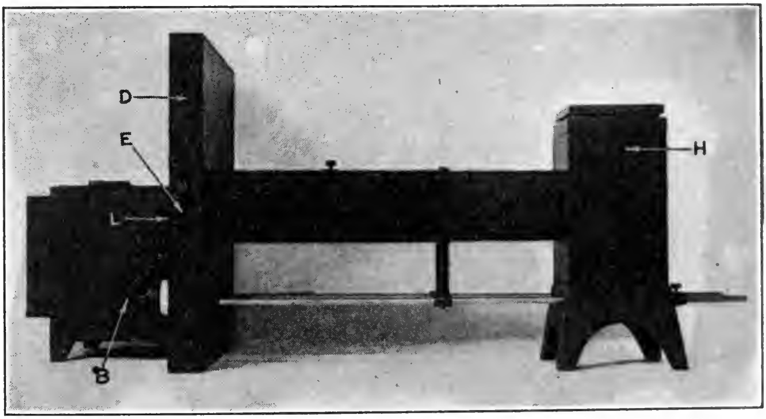

FIG. 22. Non-intermittent (one turn) sector wheel sensitometer.

of average and high-speed materials. The exposure scale obtained with this instrument consists of 23 power of root 2 steps, the maximum exposure time being 0.512 second and the minimum exposure time 0.00025 second. The mid-step (that is, No. 12) has an exposure time of 0.0112 second. The mid-point of the exposure scale, therefore, has a time factor of the same order as that used very commonly in practical work. As a result, the illumination incident upon the sensitive material is of the same order as that incident upon the photographic material when being used in practice. This adjustment of conditions minimized very greatly the magnitude of any discrepancy which may exist between sensitometric findings and the results of practice due to the failure of the reciprocity law. In this instrument the sensito-

metric strip in order to accommodate the 23 exposure steps, each of which consists of a circular area 8 mm. in diameter, must be about 10 inches long. In order to illuminate an area of this size uniformly and at a sufficient level to give the requisite exposure, a very high candle power light source would be required since of necessity it would have to be placed at a considerable distance in order to illuminate uniformly an area 10 inches long. In order to avoid the necessity of using a high candle power source a single area of the

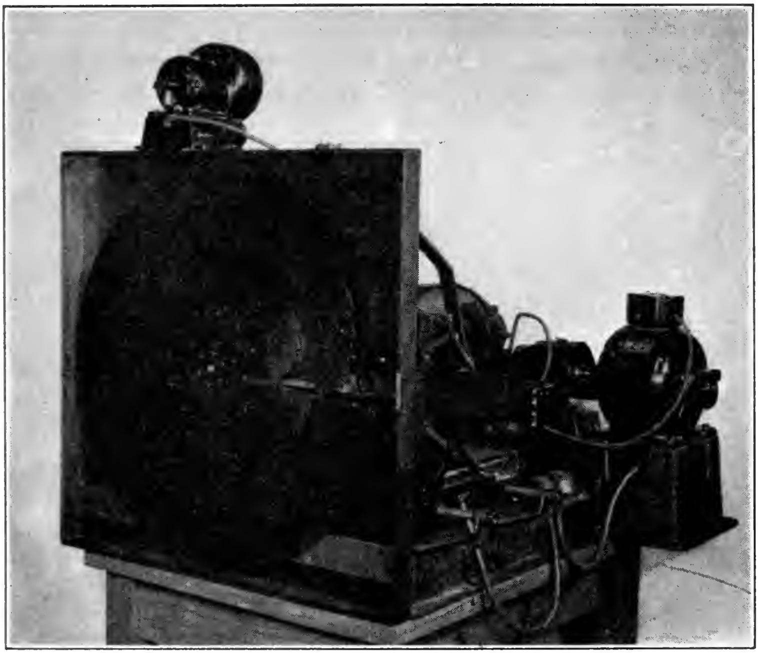

FIG. 23. Non-intermittent sensitometer employing two continuously rotating sector wheels with selector shutter.

exposure scale is illuminated by a relatively low candle power source placed within a few inches of the exposure plane. The various steps in the exposure scale are therefore exposed one after the other. Since the larger or slower moving sector disk makes one revolution in 1.8 seconds, the entire series of 23 steps is exposed in a total time of approximately 40 seconds. The lamp housing carrying the standard light source must of necessity be moved laterally by a distance representing the separation between consecutive steps on

the scale so that at the instant of exposure the optical axis of the lamp house coincides with the center of the circular area to be exposed.

Many other forms of exposure time modulators have been designed for use in sensitometric work. One using a sectored drum is described in another paper by the author in this issue of the JOURNAL.[40] Many highly specialized forms have been developed to serve particular needs, among which may be mentioned two designed particularly for motion picture processing control, namely, that described by Jones and Crabtree[41] and the Cinex sensitometer.[42] It is quite impossible in this treatment of the subject to mention all the various types which have been designed and used. The foregoing discussion should serve to give the reader a rather comprehensive idea of the general principles involved.

(Continued in the next issue of the JOURNAL)

DISCUSSION

MR. HARCUS: Will Mr. Jones please define the black body which he mentioned as the standard of color temperature?

MR. JONES: A "black body" or "complete radiator" is one which completely absorbs (and reflects none) all incident radiation of all wavelengths. There is no substance known which actually conforms to this definition although certain materials, such as carbon, approach very closely to the conditions mentioned. Most bodies reflect some of the incident radiation and, furthermore, in most cases the reflection is selective, that is, certain wavelengths are reflected to a greater or less extent than others. The theoretical black body as defined above must, from thermodynamic considerations, emit radiation in which the energy emitted at any particular wavelength or frequency is related to that frequency and to the temperature of the radiator according to a definite law, which can be derived from purely theoretical considerations. This law is known as the Wien-Planck radiation law and is given in one form in the body of the text. By means of this theoretical relationship it is possible to compute the spectral distribution of radiation emitted by a black body provided its temperature is known.

As stated above, there is no substance in nature which conforms precisely to the theoretical requirements of a complete radiator. It can be shown, however, as a consequence of Kirchhoff's law, that within an enclosed space, the walls of which are heated to some definite temperature, the radiation emitted from the walls of the heated enclosure is identical in spectral composition and in total quantity to that emitted by a theoretical black body at the same actual temperature. In practice, therefore, it is possible to realize black body radiation by constructing a furnace around an enclosure, the wall of which is pierced by an opening, the area of which is very small as compared with the total area of the interior walls. When this furnace is raised to a specified temperature the radiation escaping through the small aperture is identical with that which would be emitted by the theoretical "black body" at the same temperature as that at which the furnace

is operated. The black body therefore forms a very useful means for obtaining radiation of a known spectral composition. It is unnecessary to measure this spectral composition since it can be computed by the Wien-Planck law provided the temperature of the black body is known. The black body also forms a convenient means of specifying the temperature at which some other radiator, such, for instance, as an incandescent tungsten filament is operating. It has been found that the color of the radiation emitted by a selective radiator (such as an incandescent tungsten filament, incandescent carbon, *etc.*) at some particular temperature can be matched by the radiation emitted by a black body operated at a somewhat different temperature. The temperature at which the black body must be operated so that the emitted radiation will match in color the radiation being emitted by the selective radiator is called the "color temperature" of the selective radiator. It should always be remembered, however, that this color temperature is not identical with the true temperature of the selective radiator.

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A MOTION PICTURE LABORATORY SENSITOMETER*

LOYD A. JONES**

Summary.—*This instrument is one giving a time scale of exposure. The exposure scale consists of 21 steps in which the exposure increases by consecutive powers of* $\sqrt{2}$. *The modulation of exposure time is accomplished by means of a sectored drum driven by a synchronous motor. Two standardized electric incandescent lamps are provided, one for use in exposing negative materials and one for positive materials. These are mounted in pre-positioned bases, the lamp itself being permanently set in position at the factory so that when the base is placed on its support by means of two dowel pins the filament of the lamp must lie upon the optical axis of the instrument and in register with the distance indicating scale. Standardized dyed gelatin filters are provided so that for positive materials the exposure illumination has a color temperature of approximately 3000°K., while for negative materials the color temperature is approximately 5400°K., approximately matching mean noon sunlight in quality. Electrical measuring instruments for controlling the standard lamps are an integral part of the sensitometer. Convenient guides for positioning the film to be exposed are provided as well as a roll holder for carrying a supply of raw stock. It is estimated that the probable error in exposure does not exceed* ± *2.5 per cent.*

The foundations of photographic sensitometry were laid by Hurter and Driffield in 1890 when they devised a rotating sector wheel sensitometer, a photometer for measuring photographic density, and a method of plotting the results in a graphic form (the well-known H & D curve) by means of which certain numerical constants useful in specifying the characteristics of photographic material may be computed. They defined the speed of a photographic material in terms of the inertia, the value of exposure where the straight-line portion of the density-log exposure curve intersects the log exposure axis. Since that time a speed value determined in this manner has been referred to as the *H & D speed.* A little later Scheiner devised a method of measuring the speed of a photographic material in terms of the exposure required to produce, after development under standardized conditions, a just perceptible density. He used

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** Eastman Kodak Co., Rochester, N. Y.

a rotating sector-wheel type of sensitometer in which the time of exposure was varied continuously from one end of the scale to the other, rather than by sets as in the Hurter and Driffield instrument. A speed value based upon the exposure required to give a just perceptible density is usually referred to as the threshhold speed (Schwellenwert).

While it is true that prior to the time of Hurter and Driffield and Scheiner several different forms of sensitometers had been devised and used to some extent, they were for the most part rather crude affairs and lacked the requirements of reproducibility and precision.

During the past forty years, following the pioneer work of Hurter and Driffield, many forms of sensitometers have been invented and, with the increase of knowledge pertaining to the characteristics of photographic materials, many improvements and refinements have been introduced into the design of these instruments. There has been a tendency to build instruments of greater precision and, in many cases, specialized forms adapted particularly to certain definite problems in the field of sensitometry. No attempt will be made in this paper to give a complete review of the evolution of photographic sensitometry or a bibliography covering the field. Such treatments of the subject are available in the literature and to these publications reference should be made by those interested.[1,2,3]

Until comparatively recently, practically all sensitometers have been designed, constructed, and used by the manufacturers of photographic materials in the control of the quality of their product and for research work on the theory and practice of photography. It is of course true that a few other laboratories, such as the various national standardizing laboratories, have become interested in this type of work and have provided themselves with adequate sensitometric equipment. The demand for photographic sensitometers has not been sufficient to induce the manufacturers of physical and optical instruments to make them in quantity and offer them for sale commercially. They have been available only on special order and at the very high price that necessarily must be paid for a single instrument made according to specifications.

During the last few years, especially since the introduction of methods of photographically recording and reproducing sound, there has been a rapidly increasing need in the motion picture industry for more precise methods of controlling the photographic technic involved in the making of both picture and sound records. The grow-

ing appreciation of the value of sensitometric methods for precisely controlling the uniformity of product and as a valuable aid in obtaining the best possible quality in both picture and sound records has created a rather insistent demand for sensitometric equipment adapted particularly to the requirements of the motion picture processing laboratory. The instrument described in this paper has therefore been produced in an attempt to meet this need. While designed to meet the particular needs of the motion picture laboratory, the instrument should be found satisfactory for use wherever it is desired to make sensitometric measurements on negative and positive films or plates.

THE CLASSIFICATION OF SENSITOMETERS

While it is not proposed to discuss at length in this paper the multitudinous forms of sensitometers that have been used, or to dwell upon the merits and demerits of the various types of instruments, it does seem advisable to say a few words regarding general types and their logical classification. Reduced to the simplest principles, any sensitometer may be said to consist of two essential elements, namely, (*a*) a *source of radiation* and (*b*) an *exposure modulator*—a device for controlling the exposure incident on various areas of the sensitive material being tested. Exposure (E) is defined as the product of the illumination (I) incident upon the photosensitive surface by the time (t) during which the illumination is allowed to act. Thus,

$$E = I \times t.$$

It is evident, therefore, that exposure may be varied by controlling either the time factor (t) or the intensity factor (I) of exposure. Sensitometers may be classified most logically in terms of the manner in which the control of exposure is accomplished. If the illumination is variable, t being constant, the resultant series of exposures is referred to as an *intensity scale*. Such a result may be obtained by means of tablets consisting of a series of areas of variable light-absorbing power or by a tube sensitometer as proposed by Spurge. On the other hand, if the time factor (t) of the exposure is variable, with I remaining constant, a *time scale* of exposure is obtained. In case of the Hurter and Driffield and the Scheiner sensitometers the sector wheels, in which were cut a series of apertures of various angular dimensions, were rotated at relatively high angular velocities,

thus subjecting the sensitive material to an *intermittent illumination.* It was assumed that the photographic plate would integrate these successive exposures and that the result would be equivalent to an exposure of which the time factor was equivalent to the sum of the times for the numerous flashes composing it. It was soon found, however, that this was not the case. By operating such a device at an angular rotational velocity such that the desired series of exposure times is obtained in a single revolution of the sector wheel, a *non-*

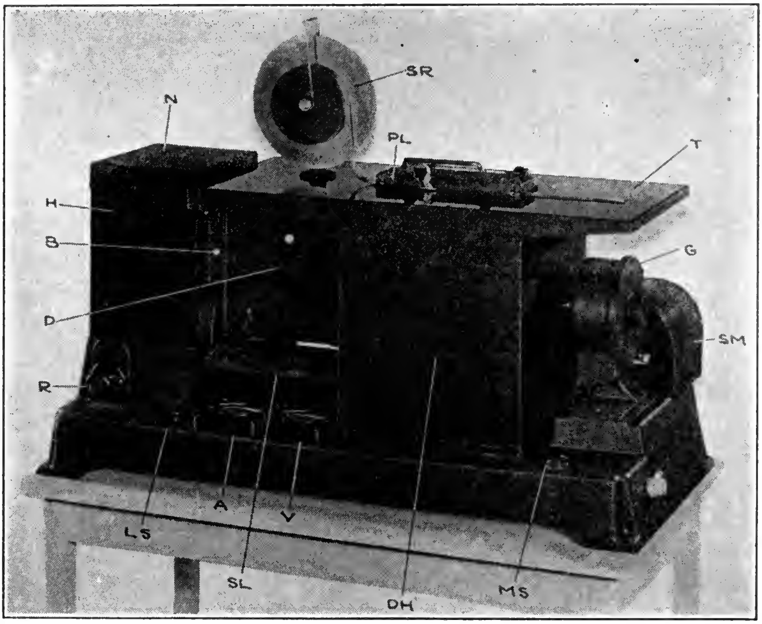


FIG. 1. Front view of the completed instrument.

intermittent time-scale of exposure may be obtained. The classification of sensitometers on a basis of the manner in which the exposure is modulated is as follows:

Type I. Intensity-scale instruments:
I variable, t constant.
Type II. Time-scale instruments:
I constant, t variable
(*a*) intermittent exposure,
(*b*) non-intermittent exposure.

The sensitometer to be described in the following pages belongs to the Type II(*b*) group.

GENERAL DESCRIPTION

A photograph of the complete instrument is shown in Fig. 1. The lettering in general is consistent with that of Fig. 2, which is a front elevation showing a partial vertical section through the optical axis of the instrument. Referring to Fig. 1, *H* represents the housing for the standard lamp. This is ample in dimensions to accommodate the lamps used and is well ventilated to prevent over-heating both

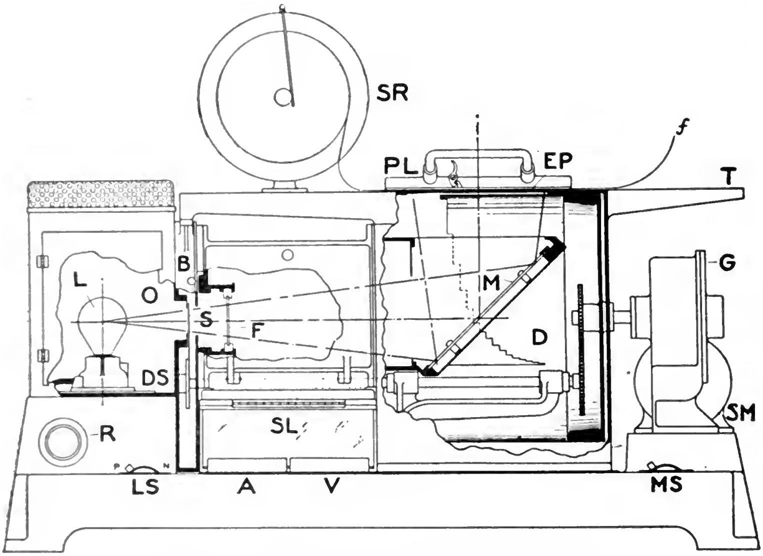


FIG. 2. Partially sectioned front elevation.

the lamp and the housing walls. In addition, a perforated metal guard, *N*, is placed over the top of the lamp house. The temperature of this guard, even after long periods of continuous operation, is only a little above that of the room in which the instrument is operated. The rectangular casing indicated by *DH* (Fig. 1) houses the exposure drum, which is driven by the synchronous motor, *SM*, through the reduction gear, *G*. The lamp house and the drum housing are connected by a light-tight rectangular tube in the front face of which is the door, *D*. When this door is opened, the filter holders are easily accessible. Directly on top of the drum housing is mounted the work table, *T*, which is approximately 16 inches wide by 34 1/2

inches long. This table consists of a cast aluminum frame on which is mounted a sheet of highly polished black bakelite. Approximately in the center of this work table is the aperture through which the illumination coming from the standard lamp, *L* (Fig. 2), reaches the exposure plane in which is placed the sensitive material being tested. The film is held in place by the platen, *PL*, which is locked in position when pulled down from its normal vertical position in which it is held by a spring.

Referring now to Fig. 2, *L* designates the standardized electric incandescent lamp, which is mounted in a light-tight housing. Light from this lamp passes horizontally through the aperture, *O*, in the front face of the lamp house. The mirror, *M*, set at an angle of 45 degrees to the optical axis reflects the light upward, and illuminates the exposure plane which is horizontal and practically coincident with the surface of the work table, *T*. The perpendicular distance from the filament of the standard lamp to the exposure plane may be varied from 75 to 85 cm., and since the maximum dimension of the filament of the standard lamp is only 3 mm. (approximately), the inverse square law holds with high precision, so that the illumination on the exposure plane may be computed provided the luminous intensity (*i. e.*, candle power) of the standard lamp is known.

The current flowing through the filament of the standard lamp is controlled by a rheostat operated by the hand wheel, *R*. The value of the current flowing through the filament of the lamp is read on the ammeter, *A*, and the difference of potential between the terminals of the lamp is indicated by the voltmeter, *V*. A suitable safelight, *SL*, is provided so that these electrical measuring instruments may be read in the dark room. It is necessary to use lamps of different candle power when testing negative and positive film. In order to obtain satisfactory precision in reading the current and voltage of these lamps it is necessary that the voltmeter, *V*, and the ammeter, *A*, shall be double-scale instruments. Moreover, in order to control successfully the current in the two lamps it is necessary to change the amount of series resistance. All the necessary changes in the wiring are accomplished by the light switch, *LS*. For instance, when it is thrown into the position designated as *P*, the connections to the electrical measuring instruments and to the controlling rheostat are correct for controlling the lamp used for testing positive film. Likewise, when the switch is thrown into the position designated as *N*, the meter and rheostat connections are so altered that

the circuits are suitable for the precise control of the standard lamp used in the testing of negative films. A selectively absorbing filter, *F*, placed as shown (Fig. 2), serves to modify the spectral composition of the radiation emitted by the standard lamps to the desired quality for use in the testing of photographic materials. The characteristics of these filters will be discussed later.

The time factor of the exposure incident upon the various areas of the material being tested is controlled by means of a rotating sector cylinder or drum. This is open at one end permitting the light from the source, *L*, to reach the mirror, *M*, and to be reflected upward to the exposure plane, *EP*. This cylindrical drum therefore encloses the mirror, *M*, and the outer surface of the cylinder lies very close to the exposure plane, *EP*. A series of twenty-one apertures, increasing logarithmically from the shortest to the longest, are cut in the wall of the cylindrical drum and thus serve to control the time factor of exposure incident upon the various areas of the sensitive material which, when placed in position, lies close to the outer surface of this rotating drum.

The drum is driven at a constant angular velocity by means of a synchronous motor, *SM*, through the reducing gear, *G*. The synchronous motor runs at 1800 rpm. when operated on a 60-cycle, a-c. supply line and at 1500 rpm. when a 50-cycle supply is employed. The reduction ratio of the reducing gear, *G*, is 1 to 150; thus the drum *D* turns at 12 rpm. when a 60-cycle supply line is used and at 10 rpm. when a 50-cycle supply is employed. The electric current for the operation of the synchronous motor and the standard lamp is supplied through a single connection which is controlled by the master switch, *MS*. When the master switch is closed the synchronous motor and, therefore, the time modulating drum, run continuously, and in order to expose the material during only one revolution of the drum, *D*, it is necessary to use a selector shutter, *S*. This is mounted on a one-turn mechanism which is directly connected to the shaft from the reducing gear by means of a pair of spur gears. When the button, *B*, is depressed, the one-turn mechanism picks up the shutter, *S*, uncovering the aperture, *O*, while the photographic material is protected by the opaque portion of the exposing drum, *D;* the aperture, *O*, closes immediately after the required series of exposures has been made. It is unnecessary to hold the button, *B*, in the depressed position until the exposure has been completed, but if this is done a second exposure will not be made because the one-

turn mechanism cannot operate a second time until after the button, *B*, has been allowed to assume its normal position and is again depressed.

For convenience in holding a reel of motion picture film the supply roll holder, *SR*, is provided. A roll of film placed in this holder is in alignment with one of the film guides provided for positioning the 35-mm. motion picture film in the exposure plane and for properly orienting it with respect to the axis of the exposing drum, *D*.

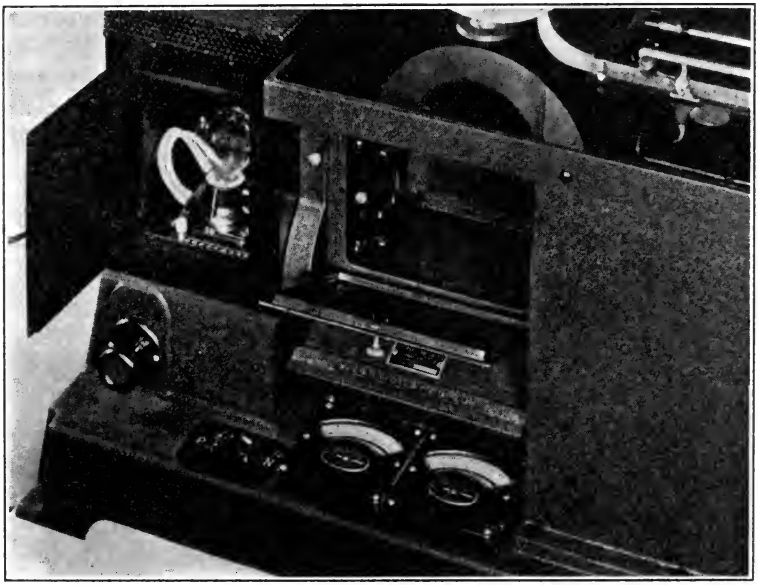


FIG. 3. Close-up showing standard lamp in position, electrical control instruments, filter holder, *etc.*

Fig. 3 is a close-up photograph of the lamp house end of the sensitometer, showing the door of the lamp house in the open position and a standard lamp in place. The door to the rectangular tube connecting the lamp housing with the drum housing is also open so that the filter and filter holder may be seen. At the lower part of the photograph may be seen the electrical measuring instruments, the lamp switch for throwing the connections from negative film to positive film testing, and the hand wheel operating the rheostat used to adjust the current in the filament of the standard lamp.

STANDARD LAMPS

For Testing Negative Film.—The standard lamp used for testing negative film is a gas-filled tungsten incandescent lamp of the headlight type, normally rated to operate at 6 volts, 6 amperes, 36 watts. Operating under these conditions the radiation emitted has a color temperature of approximately 3000°K. and the lamp does not serve as a satisfactory standard of luminous intensity because its candle power changes appreciably after a very short period of operation. In order to make a satisfactory standard of luminous intensity it is necessary to operate this lamp at a lower color temperature. For this reason, and because of other considerations, it was decided to standardize this lamp for candle power at a temperature of 2360°K. The standardizing was accomplished, after the usual pre-seasoning necessary to secure in the filament a condition of satisfactory equilibrium, on a 3-meter bench photometer, a large number of readings being taken by several observers. The reference standards of luminous intensity consisted of two groups, one obtained from the Bureau of Standards, and the other from the National Testing Laboratory. The probable error in the candle power value as finally determined is somewhat less than ±1.0 per cent. It should also be noted that when standardizing these lamps for candle-power they were mounted in a lamp house identical to that of the sensitometer so that they were, during standardization, subjected to ventilation conditions identically the same as those which will exist in practice. This is of considerable importance in standardizing gas-filled lamps because the luminous intensity is affected to a certain extent by variations in cooling, variable air current to which the bulb is subjected, *etc.* The average current required to operate these lamps at 2360°K. is approximately 4.3 amperes. This gives some idea of how much lower than the normal rating the lamp is being used It is estimated that at this efficiency the life of the lamp, as a standard of luminous intensity with a candle power tolerance of 2 per cent, should be well over 200 hours.

For Testing Positive Film.—For this purpose it is necessary to have very much higher illumination of the exposure plane. The lamp chosen for this purpose is a 6-volt, 12-ampere, 72-watt lamp of the headlight type, the filament being a single helical coil. Operated under normal conditions, the radiation emitted has a color temperature of approximately 3000°K. As stated previously, it is not feasible to standardize lamps for candle power when operating at

this color temperature. It was therefore decided to standardize these lamps at a color temperature of 2600°K., requiring a current of approximately 10 amperes. While this lamp probably will not have as long a life for a given change in candle power as the standard lamp used for testing negative film, it is considered that at this color temperature the length of life will be fairly satisfactory. It is not possible to obtain sufficient illumination on the exposure plane for exposing positive film with a standard operating at a color temperature of 2360°K.

As in the case of the standard lamps used for testing negative film, these lamps were also standardized for candle power while mounted in the lamp house as used on the sensitometer. The same extreme

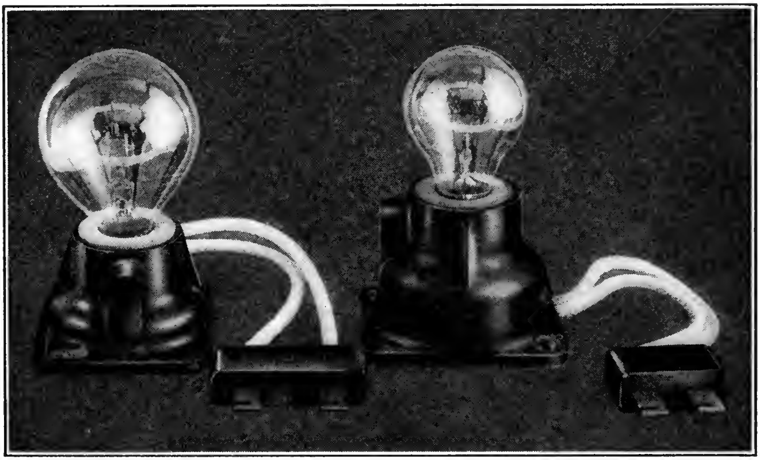


FIG. 4. Standardized lamps in prepositioned mounts.

care in sensitometric work is exercised, and it is estimated that the probable error in the values of candle power of these standards is approximately ± 1.0 per cent.

Pre-positioning Mount.—Each standard lamp is permanently mounted in a cast aluminum base, as illustrated in Fig. 4. They are soldered into position and the wires carrying the current to the filament are soldered to the bases of the lamps, thus eliminating all chances of having poor contacts in the lamp sockets. The base is so constructed that it can be placed on a suitable jig in the factory for adjusting the height and lateral position of the lamp filament, so that when the base is placed in the lamp house of a sensitometer

the filament will lie precisely on the optical axis of the instrument. Also the filament is aligned with the index line, which is engraved on the side of the base and is used to indicate on a centimeter scale mounted on the bottom of the lamp house, the distance between the filament of the lamp and the exposure plane. Fig. 5 shows a plan of the bottom of the lamp house. The distance scale, *DS*, is so arranged that the index etched on the base of the standard lamp reads directly in centimeters the distance mentioned above. The base

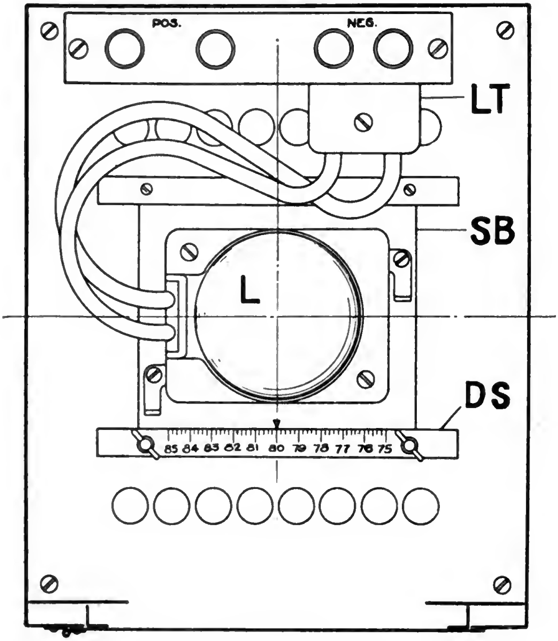


FIG. 5. Plan view of lamp house.

in which the standard lamp is mounted is provided with two positioning pins which fit into holes in the sliding member, *SB*, which can be clamped into position after proper adjustment by convenient thumb screws with knurled heads. The wires leading from the base of the lamp terminate, as shown in Fig. 4, in heavy metal terminals held in bakelite blocks. The distance between the terminals of the positive lamp is appreciably greater than that between those of the negative lamp. As shown in Fig. 5, these terminals are connected to a terminal strip at the rear of the lamp house, one pair of terminals

being for the lamp used for testing negative materials and the other for the lamp used for testing positive materials. The spacings of these terminals coincide with those attached to the lamp. It is therefore impossible for the operator, when placing the lamp in position, to make a mistake and connect it to the wrong pair of terminals.

FILTERS

For Negative Film.—The lamp for exposing negative film is standardized for candle power at a color temperature of 2360°K. It is not desirable, however, to measure the characteristics of negative materials in terms of radiation of the quality emitted by such a source. There is, of course, some question as to the best quality of radiation to choose as the standard radiation for the testing of negative materials. On the whole, it seems desirable to use radiation which approximates in quality that of mean noon sunlight. Consequently, a filter is supplied which has selectively absorbing characteristics such that when used with a light source operating at a color temperature of 2360°K. the transmitted radiation has a spectral composition approximating that of mean noon sunlight or a color temperature of 5400°K. This is the Wratten No. 79 filter. It is not feasible in manufacturing these filters to make the tolerance limits sufficiently narrow so that a sufficiently precise value of transmission can be assigned to all the individual filters produced. It is necessary, therefore, to calibrate each filter individually. This is done on a precision bench photometer equipped with a flicker photometer head. The flicker photometer method is probably the most precise and reliable where it is necessary to measure the intensities of two lights differing in color. Several observers are used in the calibration of these filters, and the probable error of the final result assigned to the filter is approximately ± 10 per cent. It is understood, of course, that this value of total transmission applies to the quality of radiation emitted by the light source operating at 2360°K.

For Positive Film.—The standard lamp used for testing positive film is standardized for candle power at a color temperature of 2600°K. This temperature is appreciably lower than that of the tungsten lamps commonly used for printing positive film and is also somewhat lower than that of the tungsten lamps used in photographically recording sound. It seems desirable, therefore, to raise somewhat the color temperature of the radiation incident on the exposure plane for the testing of positive film. For this purpose a selectively absorbing

filter (Wratten No. 78B) is supplied. The color temperature of the radiation transmitted by this filter when used with a light source operating at 2600°K. is approximately 3000°K. These filters are also calibrated individually, as described for the filters used for testing negative material. The transmission value assigned is that of the filter for light of 2600°K. quality.

The Davis-Gibson Filter.—The spectral composition of the light transmitted by the filter supplied for testing negative materials approximates with sufficient closeness that of mean noon sunlight (or black body color temperature 5400°K.) for all practical purposes. A somewhat closer approximation can, however, be obtained by using the Davis-Gibson filter.[4] Moreover, the Seventh International Congress of Photography has tentatively recommended that this Davis-Gibson two-component liquid filter, together with a tungsten lamp standardized for candle power at 2360°K., be adopted for the realization of an international unit of photographic intensity. To provide for the possibility that some users of these sensitometers may wish to set up this international standard, a Davis-Gibson filter can be supplied on special order. The construction of this filter is shown in Fig. 6. Three sheets of plane, parallel, borosilicate crown glass, *E*, are assembled with two glass separators, *C*, which space these plates exactly 1 cm. apart. Holes, *O*, drilled through the separators, provide a means of filling the cells thus formed with the proper liquids. This assembly is mounted in a metal casing, *F*, by means of a suitable cement, *D*. On one side of the metal casing is a dovetail slide which slides directly over the end of the filter support, as seen in Fig. 2 above and below the filters *F*, the end of this support being provided with flanges which fit snugly

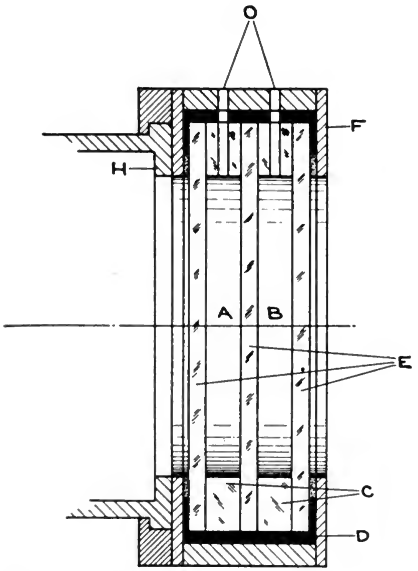


FIG. 6. Cross-section through the Davis-Gibson filter cells.

into the grooves on the filter mount and which hold it in the proper position relative to the optical axis of the instrument. The solutions of the Davis-Gibson filter to be used with the tungsten lamp operating at 2360°K. should be made according to the following formula:

A

Copper sulfate ($CuSO_4.5H_2O$)	3.707 gm.
Mannite ($C_6H_8(OH)_6$)	3.707 gm.
Pyridine (C_5H_5N)	30.0 cc.
Water (distilled) to make	1000 cc.

B

Cobalt ammonium sulfate ($CoSO_4.(NH_4)_2SO_4.6H_2O$)	26.827 gm.
Copper sulfate ($CuSO_4.5H_2O$)	27.180 gm.
Sulfuric acid (Sp. gr. 1.835)	10.0 cc.
Water (distilled) to make	1000 cc.

The complete filter to consist of a one-cm. layer each of solutions *A* and *B* in a double cell with three plates of borosilicate crown glass (refractive index, *D* line = 1.51) each 2.5 mm. thick.

In case such a filter is used, the illumination incident on the exposure plane must be corrected by multiplying the standard illumination by the ratio of the transmission for the Davis-Gibson filter (which is 13.5 per cent) to the transmission of the 79 filter supplied with the instrument. This transmission value appears on the calibration certificates supplied with each instrument.

THE REFLECTING MIRROR

The mirror, *M*, which is used to reflect the light of the source, *L*, upward onto the exposure plane, is made with great care. A sheet of borosilicate crown optical glass 3 mm. thick is used. Both surfaces are optically worked, giving a highly polished plane surface. One side is then silvered by a process designed to give a maximum reflecting power and the least possible selective absorption within the wavelength region of vital interest, that is, from approximately 360 mμ to 800 mμ. This silvered surface is then protected by heavy black lacquer. The glass used in the manufacture of these reflectors is very carefully selected in order to avoid imperfections such as bubbles, striations, *etc.*, which might cause lack of perfect uniformity of illumination on the exposure plane.

The mirror is mounted in a sheet metal sheath so that danger of breakage is minimized. This metal sheath is held in position in such

a manner that the mirror can easily be removed for cleaning. By releasing a catch, the diaphragm, which is mounted between the drum housing and the rectangular tube connecting the drum housing with the lamp housing, may be turned on its hinge so that it lies on the bottom of the rectangular tube mentioned. The opening into the drum housing is now sufficiently large so that the hand may be inserted. By grasping the sheet metal sheath, in which the mirror is mounted, between the thumb and forefinger of the left hand and by pushing upward, the lower end of the sheath may be released from the recess in which it normally rests. The mirror assembly may then be withdrawn and cleaned. It is fairly simple to replace the mirror by reversing this series of operations. The upper end of the mirror sheath must be placed in the proper position, suitable guides being provided to assist in the operation. The sheath is then pushed upward against the spring until the lower end can drop down into the retaining recess. The mirror should at all times, of course, be kept perfectly clean and free of dust and finger prints.

The reflecting power of the mirrors was measured on the precision bench photometer under conditions identical to those existing in the instrument. The usual photometric care was exercised; several observers were used and a large number of readings were taken by each observer. The final reflection value is subject to a probable error of approximately ± 1 per cent. On measuring a relatively large number of mirrors, it was found that the uniformity of the product was so great it was unnecessary to use mirrors of different reflecting powers for each sensitometer. By rejecting a relatively small number of mirrors having reflecting powers departing unduly from the mean of the group it was possible to select a group in which the variation from mirror to mirror was not greater than ± 1 per cent. The mean reflecting power value for the entire group was found to be 97.5 per cent; this value has been assumed in computing the lamp distance required to give the standard illumination on the exposure plane. This value appears rather high as compared with the published values for the reflecting power of second surface silver mirrors. It should be remembered, however, that the value mentioned above, namely, 97.5 per cent, is obtained with illumination incident at an angle of 45 degrees from the normal to the surface of the mirror and that the angle of observation is equivalent to the angle of incidence. Under these conditions it is reasonable to expect a somewhat higher value than that obtained with normal illumination

and observation. Moreover, it is well known that the reflecting power of such a mirror depends to a certain extent on the technic employed in depositing the silver surface on the glass. The technic used in the manufacture of these mirrors has been developed particularly with the object of obtaining highest possible reflection coefficient.

It is realized, of course, that a silver mirror has a certain amount of selective absorption. The best data available on this subject, however, indicate that the variation of reflection as a function of the wavelength throughout the range from 400 to 700 mμ is relatively small, being of the order of 4 or 5 per cent. It is not considered that this selectivity is sufficient to cause serious change in the quality of the illumination incident upon the exposure plane.

Exposure Time Modulator.—This consists of a thin sheet of metal in the form of a hollow cylinder, one end of which is mounted on and supported by a heavy cast iron wheel fixed directly on one end of the shaft coming from the reducing gear, G. In this sheet metal cylinder is cut a series of twenty-one openings each 10 mm. wide, the shortest of which has a length of 1 mm., as measured upon the circumference of the cylinder; while the longest has a length of 1024 mm. The lengths of these openings (and hence the time factor of exposure, t) form a logarithmic series, each one being $\sqrt{2}$ (or 1.414) times as long as the adjacent shorter one. The exposure values themselves, therefore, form an exact logarithmic series, thus permitting the resultant density values to be plotted at equal intervals on the logarithmic scale of exposure. The exposure times obtained in this manner are quite precise for all sensitometric work. The shortest slot, which is 1 mm. long, is subject to a probable error of ± 2 per cent. The third step, which is 2 mm. long, is cut with the same actual uncertainty and thus is subject to a probable error of ± 1 per cent. In the case of the fifth step, which is 4 mm. long, the probable error has been reduced to ± 0.5 per cent. For all steps longer than this the probable error in time, of course, decreases very rapidly and soon becomes negligible. It should be remembered that the shortest apertures result in the least exposures, and it is seldom that the exposures through these apertures are of very great importance since they lie on the extreme toe of the characteristic curve or even below the threshold value.

One other factor which has a bearing on the precision of timing is the constancy of the frequency of the a-c. supply line. In practically

all modern installations the frequency is maintained very constant, the maximum variation seldom being greater than one-half cycle. On a 60-cycle line this is less than 1 per cent, while on a 50-cycle line it is exactly 1 per cent. It seems reasonable to assume that the probable error in timing due to a variation of frequency is certainly, on the average, less than 1 per cent. The cast iron wheel which carries the sheet metal cylinder forming the exposing time modulator is made with a relatively heavy rim, which, due to its high inertia, tends to smooth out irregularities in angular velocity which might arise from

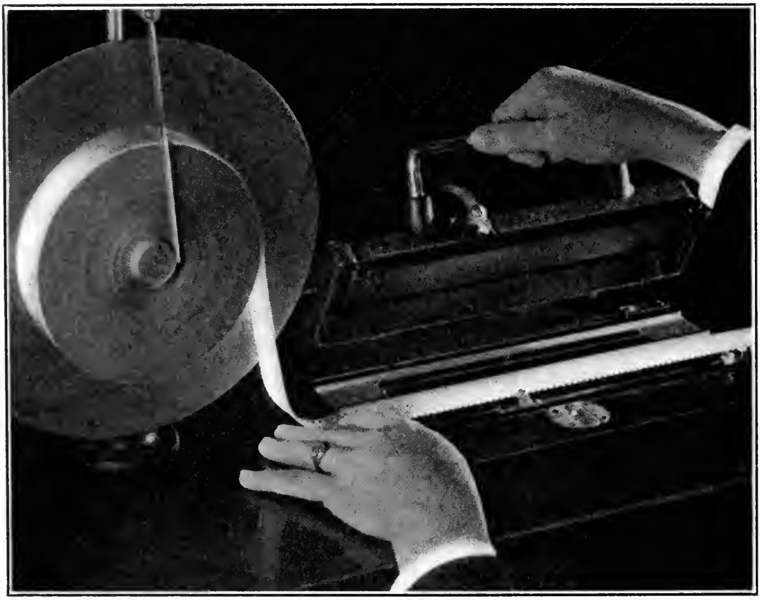


FIG. 7. The exposure plane showing film guides and platen.

imperfections in the worm and worm wheel reducing gear and from other mechanical imperfections. The greatest care has been taken in designing and constructing the instrument to obtain a mechanism which drives the exposing drum at a very uniform angular velocity.

THE EXPOSURE PLANE

In the top of the drum housing is cut a rectangular opening 7 by 21.5 cm., the greater dimension being parallel to the axis of rotation of the exposing drum and the center of the rectangle being coincident with the optical axis of the instrument where it passes through

the exposure plane. This aperture is closed by a plane parallel plate of borosilicate crown glass which has been optically worked and optically finished on both surfaces. This is recessed into the top of the drum housing so that the upper surface of the glass plate is coincident with that of the work table, *T*. Immediately over this glass plate are placed the film guides designed to position the strips of film to be exposed precisely in the exposure plane and in correct alignment with the axis of the exposing drum. The arrangement is

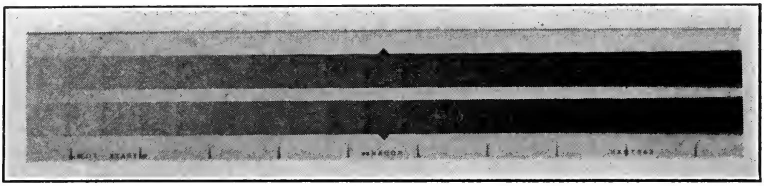


FIG. 8. Reproduction of an exposed and developed sensitometric strip.

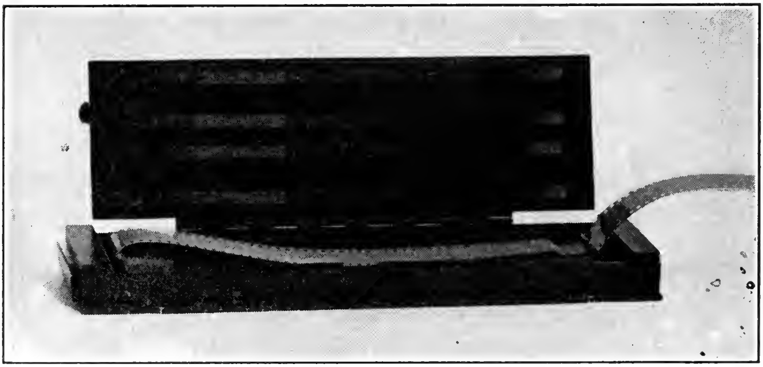


FIG. 9. Film holder for use when sensitometer is operated in an undarkened room.

illustrated in Fig. 7. It will be seen that the 35-mm. film lies in a recessed groove. After the film is placed in position, the platen, *PL* (Fig. 2), which is normally held in the position shown in Fig. 7 by a spring, is pulled down. Spring-actuated pressure pads on the under side of this platen hold the film precisely in the exposure plane during the exposure. The aperture immediately under each of the 35-mm. strips is divided longitudinally by a narrow metal bar, thus giving two separate sensitometric steps on each 35-mm. strip of film. A reproduction of an exposed and developed strip is

shown in Fig. 8. It is strongly recommended that in doing sensitometric work with this instrument, a series of density readings be made on each of the two strips, the average density values then being plotted in the usual manner. A V-shaped cut in the metal mask supporting the film in the film plane is made adjacent to the eleventh (the central) step of the exposure series. This is sometimes a useful aid in plotting the points in the correct relative position on the log *E* scale. When the platen is pulled down it is locked in position by a convenient catch, which can be quickly released after the ringing of the bell indicates the termination of the exposure.

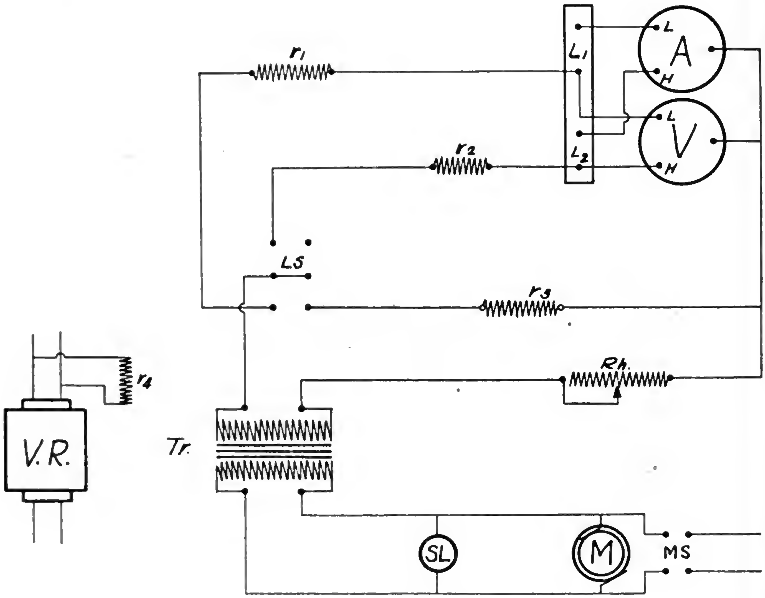


FIG. 10. Wiring diagram.

Although the instrument is made primarily for operating in a darkroom it may be desirable in some cases to use the machine in an undarkened room. For this purpose a special film holder has been designed. This is shown in Fig. 9. It is so arranged that in addition to the film necessary for receiving the sensitometric exposure, an 8-inch leader can be left on each end for convenience where it is desired to splice the film in for rack or machine development. This plate holder also holds two strips of 35-mm. film side by side. The metal mask normally forming the exposure plane can be quickly re-

moved and the plate holder substituted for it. It is, of course, possible to use strips of plates instead of film in this holder if such is desired.

ELECTRICAL CONNECTIONS

The wiring diagram of the instrument is shown in Fig. 10. The connection is made to the 110- to 120-volt, 50- or 60-cycle supply line through the master switch, *MS*. The motor and safelight lamps are connected directly across the line. The line then connects to the primary of the transformer, *Tr*, from the secondary of which supply lines are carried to the double-pole double-throw switch, *LS*, and to the control rheostat, *Rh*. The voltmeter, *V*, and ammeter, *A*, the lamp for testing negative materials, L_1, and the lamps for testing positive materials, L_2, are connected as shown. Suitable resistors, r_1, r_2, and r_3, are placed in the circuit as shown. An inspection of this diagram will show that throwing the double-pole double-throw switch, *LS*, from one position to the other makes all the necessary changes in the wiring for operating the two lamps and for changing the instrument connections from low to high range scales or *vice versa*. The ammeter and voltmeter are made by the Weston Electrical Instrument Company and have a guaranteed precision of ± 0.5 per cent.

Current Supply.—The sensitometer is designed for a-c. operation at approximately 110 volts, 50 or 60 cycles. It is very important that the proper current, as designated by the calibration data supplied with each standard lamp, be maintained at all times when the exposure is being made. If the line voltage is not constant it is extremely difficult, even by paying continual attention to the meter reading, to maintain a sufficiently precise setting of current. On such lines it is recommended that a voltage regulator be used. Since many motion picture laboratories are already equipped with carefully regulated a-c. lines for printing and other purposes, it did not seem desirable to build into this sensitometer a voltage regulator which would only add to the cost without being of advantage if a regulated line is already available. Arrangements have been made, however, to equip these instruments with the voltage regulators where required. The attachment of a voltage regulator requires a certain amount of rewiring and it is extremely desirable that this be done at the factory. A voltage regulator for use on either 50- or 60- cycle, 110- to 120-volt lines can be supplied if required. It should be remembered

that for some photographic materials the photographic intensity of a tungsten lamp varies seven or eight times as fast as the current. Thus a variation of 1 per cent from the specified value of current may cause as much as an 8 per cent variation in the photographic intensity of the standard source. It is obviously necessary, therefore, to maintain the current very accurately at the specified value if reproducible results of high precision are desired.

CONSTANTS OF THE INSTRUMENT AND CALIBRATION DATA

Exposure Time, t.—In Table I are given data relative to the exposure time for each step of the sensitometric scale. In the column designated as l are given the lengths of the various slots in the exposing drum. In the columns designated as t are the corresponding times of exposure when the instrument is operated on 60- and on 50-cycle supply lines. The columns designated as log t are the logarithms of these exposure times. It will be noted that when operating on 60 cycles the minimum exposure time is 0.004+ second, while the maximum exposure time is 4.16 seconds. The mean time, that is

TABLE 1

Exposure time (t) constants for the instrument

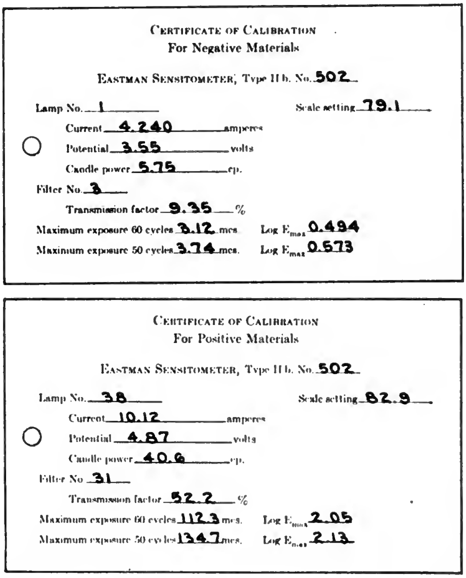
		60 Cycles		50 Cycles	
Step. No.	l	t	Log t	t	Log t
1	1024.0	4.16	0.619	4.99	0.698
2	724.0	2.94	0.468	3.53	0.548
3	512.0	2.08	0.318	2.49	0.396
4	362.0	1.47	0.167	1.76	0.246
5	256.0	1.04	0.017	1.25	0.097
6	181.0	0.735	$\bar{1}.866$	0.882	$\bar{1}.945$
7	128.0	0.520	$\bar{1}.716$	0.624	$\bar{1}.795$
8	90.5	0.367	$\bar{1}.565$	0.441	$\bar{1}.644$
9	64.0	0.260	$\bar{1}.415$	0.312	$\bar{1}.494$
10	45.3	0.184	$\bar{1}.265$	0.220	$\bar{1}.342$
11	32.0	0.130	$\bar{1}.114$	0.156	$\bar{1}.193$
12	22.6	0.0919	$\bar{2}.963$	0.110	$\bar{1}.041$
13	16.0	0.0650	$\bar{2}.813$	0.0780	$\bar{2}.892$
14	11.3	0.0459	$\bar{2}.662$	0.0551	$\bar{2}.741$
15	8.00	0.0325	$\bar{2}.512$	0.0390	$\bar{2}.591$
16	5.66	0.0230	$\bar{2}.362$	0.0276	$\bar{2}.440$
17	4.00	0.0163	$\bar{2}.212$	0.0195	$\bar{2}.290$
18	2.82	0.0115	$\bar{2}.061$	0.0138	$\bar{2}.140$
19	2.00	0.00812	$\bar{3}.910$	0.00974	$\bar{3}.988$
20	1.41	0.00574	$\bar{3}.759$	0.00689	$\bar{3}.838$
21	1.00	0.00406	$\bar{3}.608$	0.00487	$\bar{3}.688$

the time for the middle step (step No. 11) of the exposure series, is 0.130 second. These exposure times are relatively short as compared with those usually found in time scale sensitometers and are, in fact, quite comparable with exposure times used in practice. They are not, of course, as short as the exposure times used in photographically recording sound, but are very comparable with the times used in printing motion picture positive film and with those involved in making motion picture negatives. The fact that these exposure times are comparable with those used in practice should tend to minimize any errors due to the reciprocity law.

Illumination on Exposure Plane.—

For negative film
- Illumination (I) = 0.750 meter candle
- Log I = $\bar{1}.875$
- Quality = approximate mean noon sunlight, or color temperature 5400 °K

For positive film
- Illumination (I) = 27 meter candles
- Log I = 1.431
- Quality = color temperature 3000 °K.



CERTIFICATE OF CALIBRATION
For Negative Materials

EASTMAN SENSITOMETER, Type II b. No. 502

Lamp No. 1 — Scale setting 79.1
Current 4.240 amperes
Potential 3.55 volts
Candle power 5.75 cp.
Filter No. 3
Transmission factor 9.35 %
Maximum exposure 60 cycles 3.12 mcs. Log E_{max} 0.494
Maximum exposure 50 cycles 3.74 mcs. Log E_{max} 0.573

CERTIFICATE OF CALIBRATION
For Positive Materials

EASTMAN SENSITOMETER, Type II b. No. 502

Lamp No. 38 — Scale setting 82.9
Current 10.12 amperes
Potential 4.87 volts
Candle power 40.6 cp.
Filter No 31
Transmission factor 52.2 %
Maximum exposure 60 cycles 112.3 mcs. Log E_{max} 2.05
Maximum exposure 50 cycles 134.7 mcs. Log E_{max} 2.13

FIG. 11. Calibration certificates supplied with each instrument.

Certificates of Calibration.—In Fig. 11 are shown reproductions of certificates of calibration which are supplied with each instrument. These contain values of the current and voltage at which the standard lamp must be operated and the candle power of the lamp when operated at these specified current and voltage values. The certificates also contain the values of transmission of the filters supplied with the instrument. The scale setting as shown on the certificates is computed so as to give the standard illumination on the exposure plane when using the particular standard lamp and filter as specified in the certificates.

In computing these values it is assumed that the glass plate immediately under the exposure plane has a transmission value of 0.92.

This is assumed on a basis of a 4 per cent reflection loss at each surface and further assumes that no measurable absorption takes place within the glass plate itself. The reflection coefficient for the mirror, M (Fig. 2), is taken as 97.5 per cent, the derivation and reliability of this value having already been discussed.

At the bottom of the certificates of calibration will be found the maximum exposure values and the logarithm of the maximum exposure values when the instrument is used both on 60 and 50 cycles. These values are of use in establishing an absolute scale of log exposure in case this is desirable. In most cases where the instrument is used primarily as a control of photographic processing it will be quite unnecessary to plot the density values against the absolute log E values, a relative log E scale being entirely satisfactory for most purposes.

The author wishes to acknowledge the very material assistance which has been rendered by other members of this laboratory staff in the design, construction, and calibration of this sensitometer. In particular he wishes to express his appreciation to Mr. Oran E. Miller for his careful attention to the many details involved in the design of the instrument, to Mr. Fordyce Tuttle, who is in charge of the instrument shop in which the instrument was built, for his excellent work in the execution of the design; and to Mr. W. T. Clark for his able assistance in the final calibration of the instrument.

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DISCUSSION

MR. J. CRABTREE: Does the reflecting power of the small mirrors remain constant?

MR. JONES: We have had no reason to run any actual life tests. The Bausch & Lomb Company has investigated the permanence of mirrors at some length and they assure us that those mirrors, used under the conditions found in this

instrument, should not change materially over a period of years. We have every reason to believe that they will remain constant. It is a simple matter to check up the illumination on the exposure plane.

MR. FRAYNE: Do you expect any trouble in the field due to possible fluctuations of the line voltage during the 4 seconds taken to operate the instrument? Fluctuations occurring during the four seconds, of the order to 2 to 3 per cent, may be encountered, and I wonder if any serious difficulties might result.

MR. JONES: That is a point which I entirely skipped in my discussion, but which was considered very carefully. We were advised that practically all laboratories are equipped with voltage controlled lines, and that in most cases a sensitometer would probably be operated on a line where the voltage is controlled very carefully. However, we are prepared to supply voltage regulators with the instrument. These have been designed with great care, and are guaranteed by the manufacturer to a variation of plus or minus $^1/_4$ of 1 per cent for a 10 per cent variation of voltage of the supply line. That is a very important point. For anyone who is contemplating the use of this instrument on a-c. lines not closely regulated, the sensitometer should be equipped with the voltage regulator. These instruments can be supplied with or without a regulator, but we recommend very strongly, in case the customer has not a carefully regulated line, that he purchase an instrument with the regulator. The photographic candle power of a lamp varies about 8 times as fast as the voltage. It is of utmost importance that the instrument be supplied with a very constant potential.

MR. FRAYNE: I believe that in practice the voltage regulation in the laboratories is not on the line but on the d-c. generator supplying the voltage to the printer lights. I wonder if it is possible to substitute a d-c. lamp of the equivalent wattage for the a-c. lamp as now supplied.

MR. JONES: It would not be possible without some modification of the wiring on account of the transformer incorporated in the circuit. If at a low voltage a 6-volt lamp from a high-voltage d-c. line were used, it would be necessary to reduce the voltage by a series resistance. This can be done, of course, if desirable.

MR. JEFFERSON: I understand that the Westinghouse Company is bringing out voltage regulators which will keep the voltage correct to within $^1/_4$ per cent on either a-c. or d-c. lines.

EASTMAN SUPERSENSITIVE MOTION PICTURE NEGATIVE FILM*

EMERY HUSE AND GORDON A. CHAMBERS**

Summary.—*The advantages which the new supersensitive film has over the present type of film are described, and comparative photographic characteristics of the two types of film are presented. In addition, the paper includes a brief discussion of the particular features involved in the use of the faster film, such as the difference in color sensitivity of the two types, and relative contrast, and the rendering of details in shadows and soft highlights. Users of the new film are cautioned against the danger of processing it when using the present safe lights, on account of the greater speed of the emulsion. The paper concludes with a description of the gray base which has been provided, mainly for the purpose of avoiding halation.*

As the name "supersensitive" implies, the new Eastman supersensitive panchromatic type 2 emulsion is extremely fast, but because of its name this new film must in no way be confused with a hypersensitized film. In the past when an emulsion of very high speed was desired for color photography, filter shots, or trick work, it was customary to especially treat the film in some kind of sensitizing bath. This bath caused a general increase of speed, and particularly increased the speed of its reaction toward red light. However, the sensitized film had certain disadvantages, such as its cost, its lack of keeping-qualities, and its propensity to produce fog. In the supersensitive type of emulsion these disadvantages are entirely overcome. The increased speed of the new film is obtained during the course of manufacture. It is sufficient to say, therefore, that the supersensitive film is not a hypersensitized film. Furthermore, it exhibits the same keeping-qualities, and shows identical physical characteristics to those shown by the present panchromatic films.

A complete study of any type of film emulsion is best accomplished by making both sensitometric and practical camera tests. This paper will not deal in any way with the camera tests, but will consider in some detail the sensitometric characteristics of the new emulsion

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** West Coast Division, Motion Picture Film Dept., Eastman Kodak Co.

as compared with the present panchromatic emulsion. The point of major importance in considering the new film is its greatly increased speed. The data obtained by sensitometric measurements can be, and have been, checked by camera exposures.

Sensitometry involves a study of known values of exposure as related to the amount of silver (density) which these exposures produce upon the film after development. The standard sensitometric curve is therefore one in which is shown the relationship between exposure (expressed logarithmically) and the densities produced. It is from curves of this type that the sensitometric characteristics of the films under investigation have been studied.

Another important point that must be considered is in relation to the quality of the light to which the film is exposed. For this reason

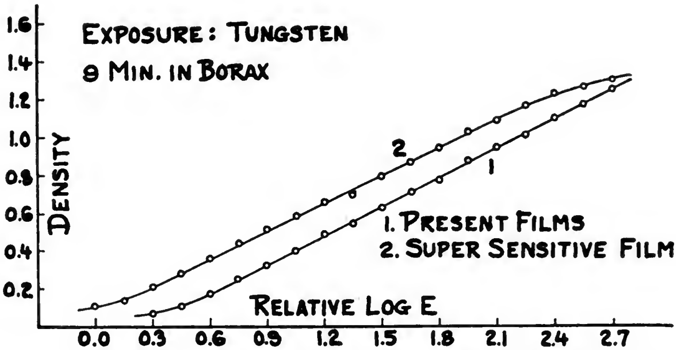


FIG. 1. Sensitivity curves of present film and supersensitive film.

sensitometric tests have been made exposing the film to daylight and to light emitted by a tungsten source. Inasmuch as the method of testing an emulsion when exposed to any kind of source of light is practically identical, we shall, for the sake of simplicity, consider only curves obtained on exposing the film to the light of a tungsten source.

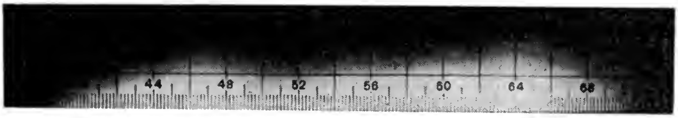
Fig. 1 shows the sensitivity curves of the present and the supersensitive types of film, exposed to a tungsten source and developed for a fixed time of nine minutes in a standard borax developer. It will be observed that the curve for the supersensitive film lies above the curve for the present type of film, and that the separation between these curves is a measure of the difference of speed of the two films. In making a numerical estimate of the speed we do not consider the actual densities produced by given exposures; it is customary to

deduce the speed from the exposure indicated by the point where the linear portions of the sensitivity curves, produced, intersect the exposure axis. Speed is usually defined by the following formula:

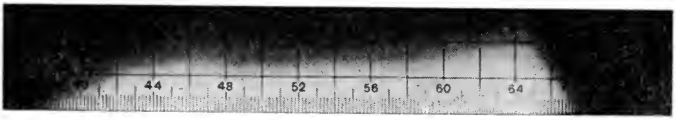
$$\frac{1}{i} \times C = \text{speed}$$

in which i, the inertia, is the exposure indicated by the point of intersection and C is an arbitrary constant. For the curves shown in Fig. 1 we find that the speed of the supersensitive film, as represented by curve No. 2, is three times that of the present type of film. Identical tests made with daylight exposures show that the supersensitive film has twice the speed of the present type. Attention should be

Tungsten.



Present films.



Supersensitive.

FIG. 2. Spectrograms of the two types of films, obtained by exposing to the light of a tungsten source.

called to the marked difference between the curves in the region of low exposure, that is, in the "toe" of the H & D curve. In this region the supersensitive film definitely differentiates between exposures of very low intensities. Particular reference is made to exposures less than that indicated by relative log $E = 0.3$.

The cause of the difference between the speeds of the two types of film when exposed to a tungsten source and to daylight, or to any other source, is entirely dependent upon the color distribution of the light emitted by the source, and its effect upon the emulsion as determined by the color sensitivity. It is generally known that tungsten sources, for example, radiate a greater proportion of red light than is found in daylight, and the difference between the speeds of the two

films indicates that the supersensitive film must be more sensitive to red light than the present film. It is mainly for this reason that the ratio of the speeds of the two films is greater when exposed to the light of a tungsten source than when exposed to daylight.

The difference in color sensitivity of the two types of film is shown in Fig. 2. This illustration shows prints of spectrograms of the two types of film when exposed to the light of a tungsten source. Comparisons of speed should not be made from these prints as the prints have been so made as to show the regions of the spectrum in which each emulsion is sensitive. The numbers in Fig. 2 represent wavelengths; beginning at 0.40, in the blue-violet region, the wavelength increases through the blue-violet, blue, green, yellow, and orange as far as red, at a wavelength of 0.68 microns. The supersensitive film

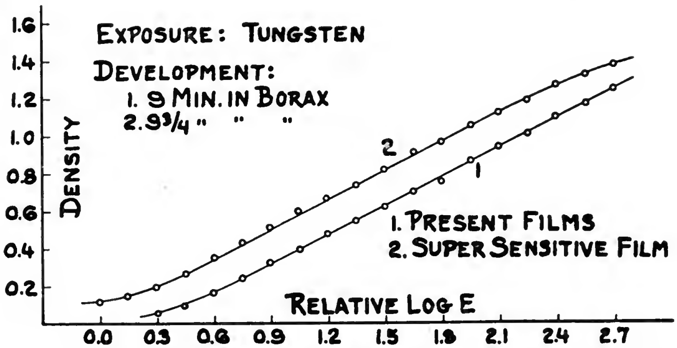


FIG. 3. Curves showing times of development required to produce the same gamma.

shows an increase of sensitivity around 0.64 microns. Its sensitivity drops abruptly at the long-wave limit of visibility, whereas the present type of film is quite sensitive to the deep red, and even encroaches upon the near infra-red. This is an important advantage as it is the sensitivity at the longer wavelengths that contributes to the production of chalky highlights when tungsten sources are used. This is eliminated to a marked degree in the supersensitive film.

A complete study of the color sensitivity of an emulsion requires the measurement of speed at the three major portions of the visible spectrum, namely, blue, green, and red. For the purpose of obtaining such information, speed curves similar to those shown in Fig. 1, later substantiated qualitatively by exposures made in a camera, were made, exposing the film to daylight through the No. 49 (blue),

58 (green), and 25 (red) filters. Such tests showed that the supersensitive film has 75 per cent more speed when exposed to the blue, 200 per cent more when exposed to the green, and 400 to 500 per cent more speed when exposed to the red than the present film.

Another important thing to consider when comparing the two types of film relates to the contrast and to the rendering of details in the shadows and softer highlights. Fig. 3 shows, for exposures to tungsten sources, the difference between the times of development required to produce in the two types of film equal degrees of contrast (gamma). Both curves of Fig. 3 have the same gamma; the data show that it was necessary to develop the supersensitive film three-quarters of a minute longer to produce this effect. Furthermore,

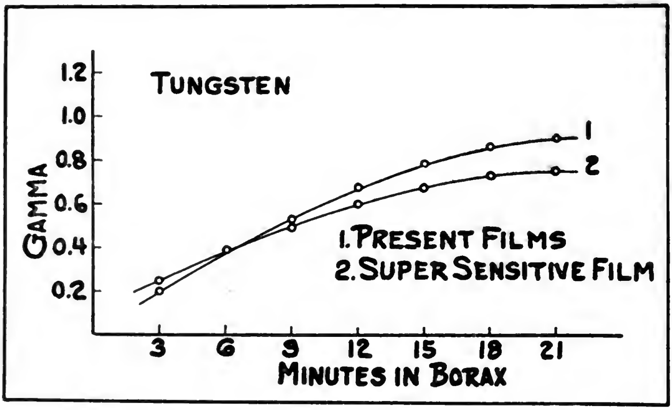


FIG. 4. Time-gamma curves of the two types of film.

greater density is obtained in the low-exposure region, due mostly to the greater speed of the supersensitive emulsion. It is this ability to respond to and differentiate between these low intensities which gives to the supersensitive film its great capability of rendering details in the shadows. On the other hand, it will be observed that in the high-exposure region the curve of the supersensitive emulsion tends to bend toward the horizontal, whereas the curve of the present type of film continues as a straight line. This is at least true of the series of exposures shown in the illustration. This characteristic leads to a softer rendering of highlights and yet permits a very definite separation of highlights, providing good detail in this region.

Fig. 4 shows in more detail the relationship existing between the contrast (gamma) and the time of development. These curves,

commonly referred to as time-gamma curves, show the rate at which the gamma increases with the time of development. The rate of increase of the gamma of the supersensitive film is appreciably less than that of the present type of film, as inspection of the curves of Fig. 4 will show. This means that there is much less chance of over-developing or under-developing the film during processing. Errors of the order of 25 per cent in the time of development will show much less effect on the supersensitive film than on the present film. In other words, the new film provides for a much greater "development latitude."

One important caution must be mentioned; due to the great sensitivity of the new emulsion, the film cannot be successfully handled unless the light emanating from the present safelights is considerably reduced. It would be best to handle the film in total darkness; no doubt this will be done, inasmuch as many camera loading rooms and laboratories where negative film is processed in machines are kept quite dark, if not totally so. It is felt, therefore, that this requirement will not cause any great hardship; however, this word of caution is considered necessary on account of the greatly increased speed of the new film with regard to both white and colored light.

GRAY BASE FILM

Since the introduction of the supersensitive negative another decided improvement has been made which will generally enhance photographic quality. The emulsion is now coated on a gray base, mainly for the purpose of preventing halation. The gray base was introduced to the motion picture industry in May, 1931.

Halation has always been a source of trouble for photographers. The halation which appears as a glow encircling the highlights of the picture is due to the reflection by the rear surface of the film base of the light which has passed through the emulsion and the support, so that it becomes incident upon the sensitive surface a second time, this time from the rear. In the case of glass plates where the thickness of the emulsion support is appreciable, halation is very serious, while in the case of the thin film base the effect is so reduced that in ordinary photography it is negligible. Indeed, one of the advantages that has always been claimed for film, as compared with plates, is the great freedom from halation which the former provides.

The importance of halation, however, is a relative matter. A spreading of light which is utterly negligible in an 8 × 10 picture

may be serious in a smaller picture, and very serious indeed in a motion picture frame. For this reason negative film has for years been made with a double coating of emulsion, so that in addition to other benefits conferred by this procedure, halation is reduced to a minimum. When working with glass plates photographers have been accustomed to reduce the halation by coating the backs of plates with a "backing" which prevented the reflection of light from the rear surface of the glass and which could be removed during or after development. "Backing" is a messy operation and the dissolving of the backing in the developer is not at all desirable, but its effect in diminishing halation has lead to a wide use of this method.

In the motion picture industry it has not seemed desirable to place

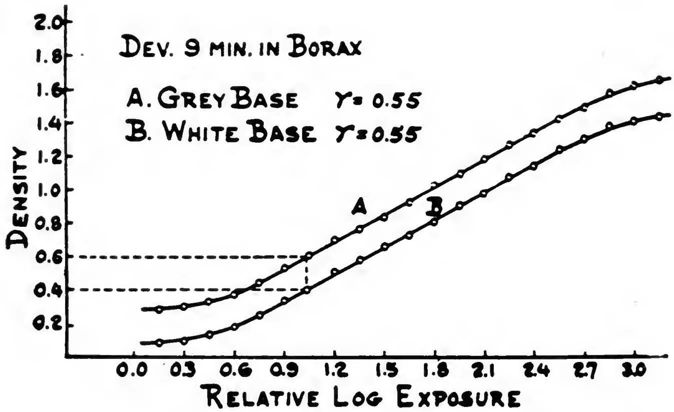


FIG. 5. Curves of white and gray base films.

a soluble backing on negative film, but fortunately the same result can be obtained in another way. For many years the Research Laboratories of the Eastman Kodak Company have been experimenting with backings, as a result of which they have evolved a special light gray backing which can be applied to negative film and which, in conjunction with the double coating, obviates halation completely. This gray base does not change during processing and so involves no danger of chemical trouble.

It is of importance to note that anti-halation backings have no direct chemical effect upon the emulsion characteristics. However, a decided improvement of photographic quality is effected by avoiding the scattering of light by the base side of the film. The absence of scattering provides an *apparent* change in the characteristics of the

emulsion, although this effect is reached indirectly and not as an actual alteration of the emulsion.

Results obtained by making motion pictures with the new film show a marked improvement in sharpness, detail in the highlights, and an over-all improvement of photographic quality. The effects of halation are far-reaching, and a film which avoids these effects should be of the utmost value to the cameraman.

DISCUSSION

MR. MOLS: May not the present film be used for making night shots in the daytime, where light green fields are often encountered as a background? The regular panchromatic film required a great deal of care when making night shots during the daytime due to the fact that there was a tendency for the green to show white. I wonder if in this more sensitive type of negative such a condition might not be corrected.

MR. HUSE: I believe that a great deal of "over-correction" is in reality under-exposure. The old type of film was not sufficiently fast, particularly in the red where you needed the speed most when making night shots in the daytime, using deep red filters. But the new film has sufficient speed to permit most satisfactory work of this kind. It is possible to get a much better timed exposure and to do away with any sharp contrast which might appear to be over-correction and which in reality is partial over-correction combined with under-exposure.

MR. PALMER: Will you explain the physical difference between non-halation film and ordinary film?

MR. HUSE: Non-halation film contains a neutral gray dye which prevents halation. This will cause an increase of about 1 to $1^1/_2$ printer points in printing; otherwise, there is no change required in the composition nor are any other difficulties found in printing through it. This film was presented to a group of camera and laboratory men last week and all the laboratory men present thought that this feature would not introduce any difficulties whatsoever.

MR. KAINS: Is any special handling of this super-speed film required for use in the tropics?

MR. HUSE: No more precaution is necessary in using the supersensitive film than in using any other type of film. Any type of film will deteriorate under high temperature and high humidity and the physical characteristics of this film are identical to those of any panchromatic film. As a matter of fact, our films are being shot in the tropics, and I heard only the other day that we had some films sent back to us from Europe which were shot in the tropics not more than a month ago.

THE ELECTROLYTIC REGENERATION OF FIXING BATHS*

K. HICKMAN, C. SANFORD, AND W. WEYERTS**

Summary.—*It has long been known that commercial fixing solutions containing hypo, sulfurous acid, and silver bromide can be electrolyzed between inert electrodes by very small currents. Attempts to increase the current density to practical amounts have caused discoloration of the hypo, ruining its utility. It has been found that suitable adjustment of the acidity and the sulfite content of the solution, combined with extremely rapid agitation, enables the silver to be plated at current densities varying from 2 to 10 amperes per square foot. Plating cells have been built comprising alternating elements of graphite anodes and stainless steel cathodes, 4 feet square, each presenting a total active surface of about 7 square feet. Thirteen pairs are used in a paraffined wood tank through the ends of which a stout stainless steel shaft is fastened. The shaft is covered with hard rubber and is furnished with spokes or paddles which rotate, four in number, in the spaces between the plates. Special water protected bearings have been developed to isolate the naked metal from the hypo solution at the gaskets on the box ends before the shaft meets the true suspension bearings.*

Five cells capable of handling 150 million feet of mixed positive and negative 35-mm. film each year have been installed in the new laboratory erected by Metro-Goldwyn-Mayer at Culver City. A smaller installation of 3 cells is near completion at the Universal Studios, Hollywood. Further details of the erection and working of these plants will be published in a later paper.

The recovery of silver from spent fixing baths is practiced by most film laboratories and the procedure is well known.[1] The sulfide precipitation process remains the general favorite[2] because, in spite of messiness and the uncertain control of refining charges, the requirements in skill and labor are few.

The amount of labor, or research to economize labor, which a process will carry is not a fixed quantity but increases with the growth of the operating unit. Processing laboratories have advanced to such a size that it would be profitable to install elaborate recovery systems, even at the cost of higher labor charges and skilled supervision, if increased yields were available. In the search for a suitable process it has been considered essential to find ways of using the fixing

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** Kodak Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

bath more than once, preferably in a continuous-flow cycle. Of the regeneration schemes that have been examined the more important are:

(1) Precipitation with sulfide, centrifugal separation of sludge, treatment of liquor with sulfite to remove sulfide, replenishing and recirculation to processing machines. Disadvantages are smell, mess and labor of handling sludge, and refining charges.[3]

(2) Precipitation with hydrosulfite. Disadvantage: the bath must be made alkaline for treatment and then re-acidified. The hardener becomes lost on the way.[4]

(3) Precipitation with zinc. Disadvantage: the bath becomes loaded with zinc thiosulfate and removal of silver is difficult unless the solution is boiled.[5]

(4) Electrolysis. This process offers many advantages and will be considered in detail.[6]

The Electrolysis of Hypo Containing Silver.—When an electric current is passed between two uncorrodible electrodes* immersed in a water solution of a metallic salt,[7] oxygen gas is generally evolved at the *anode* or positive pole, and metal is deposited at the negative *cathode*. The metal may be powdery, crystalline, dull or bright, loose or adherent, according to the conditions. Silver deposited from silver nitrate or other simple salts is loosely attached to the electrode in a granular or micro-crystalline state. Bright, adherent deposits are obtained from the double cyanide of silver and potassium, and from certain ammoniacal[8] solutions.

When a current of usual plating density is passed through thiosulfate solutions containing silver *no* oxygen is liberated at the anode, and a black cloud[1] of silver sulfide is liberated at the cathode which soon obscures the solution. If the current is diminished a hundredfold to a density of less than 50 milliamperes per square foot, silver is very slowly deposited in adherent metallic form. Although such slow deposition is commercially useless, it shows that the plating reaction is fundamentally possible and suggests that deposition at higher current densities is spoiled by side reactions.

The electrolytic separation of a metal from a simple salt occurs in the following stages:

On dissolving in water the salt *ionizes*[9] into two components oppositely charged electrically:

$$AgNO_3 \rightleftharpoons Ag^+ + (NO_3)^-$$

* Carbon or platinum, for instance.

When an electric current is passed the positive silver ion moves to the negative pole, gives up its charge, and deposits in the form of metallic silver on the pole piece. The nitrate ion NO_3^- moves to the positive pole and, at the moment of liberation, decomposes water, forming nitric acid and oxygen:

$$2NO_3^- + 2\oplus + H.OH \rightarrow 2HNO_3 + O_2$$

The separation of metal from potassium cyanide[10] or silver thiosulfate occurs differently. The salts yield ions, thus:

$$NaAg(CN)_2 \rightleftharpoons Na^+ + Ag(CN)_2^-$$
$$NaAgS_2O_3 \rightleftharpoons Na^+ + AgS_2O_3^-$$

Note that the silver is now in the negatively charged particle and is driven away from the negative pole toward the positive pole. On discharging at the latter pole, some of the cyanide ions and all the thiosulfate ions are oxidized and the silver remains in the solution. The sodium ions discharged as metallic sodium atoms at the cathode are so reactive that they decompose any ions in their vicinity yielding silver if there remain enough $AgS_2O_3^-$ ions; otherwise they reduce water to hydrogen, or reduce thiosulfate to a series of compounds, most of them fatal to good silver plating.*

It is not proposed to detail the very complex chemistry** of the case more than to stress the fact that the silver deposited from a used fixing bath is *secondary* silver, liberated from complex silver particles which are all wandering *away* from the only place where they can deposit. It is the problem of the recovery chemist to see that, in spite of the migration, there are always enough silver ions in the neighborhood of the cathode to react with the electric charge or with sodium atoms; otherwise the hypo will be attacked, yielding among other things sodium sulfide, which will in turn precipitate some silver sulfide. It will be revealed presently how even a little silver sulfide can spoil a growing silver surface.

The obvious way to counteract migration is to use a bath which is rich in silver, and by vigorously stirring the bath to renew the

* It has been stated by many observers[7] that in reality plating occurs by the discharge of true silver ions liberated from the silver thiosulfate complex by secondary ionization. According to this picture, the silver thiosulfate ion is merely the "host" for the silver ion. Since the host is migrating from the cathode, the depletion of silver ions is accounted for to the same extent.

** This will be described fully in the *Journal of Industrial and Engineering Chemistry*.

solution in the neighborhood of the electrodes. The ratio of permissible current to silver content is shown in Fig. 1. The quantity of current that the cathode can tolerate increases enormously with agitation,[11] and with quite violent stirring the current density can be increased hundreds of times without generating sulfide. The relation between the permissible current and the surface velocity is shown in Fig. 2. Rates of flow greater than four feet per second, or less than one foot per second have not proved economical.

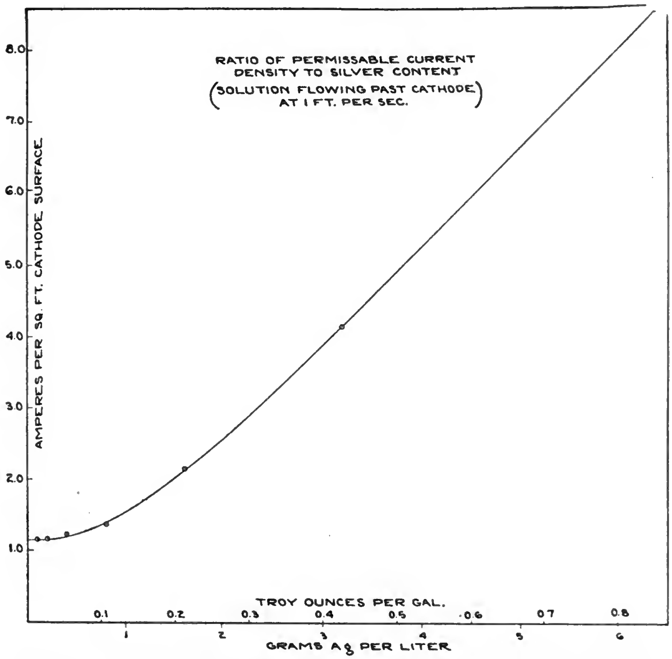

FIG. 1. Ratio of permissible current to silver content of bath.

Consider now a certain element of cathode surface past which a stream of electrolyte is flowing at a velocity sufficient to give metallic plating. Suppose there are present particles of dirt, sulfide precipitate, or what not. Some of the particles will be electrically neutral, and some will be positively and some negatively charged. Of these, some of the positively charged particles will deposit on the cathode. Again, of those that adhere, some will conduct current and some will not. The conducting particles project into the stream and are in such a position for preferential plating that they will be-

come sheathed in silver, forming a substantial nodule. These parts of the electrode surface which are surrounded by nodules are now so sheltered from the agitation that the critical limit is passed and silver sulfide is generated. The sulfide particles are washed into the main stream, and are in turn attracted to new places on the cathode, where they generate silver nodules. Thus, in a short time a small amount of solid impurity will have poisoned a large area of electrode. After *agitation*, therefore, the next problem is *filtration*, before and *during* electrolysis.

Even with the most carefully purified silver thiosulfate solutions the silver surface becomes poisoned before it is very thick. This is because the silver deposits many minute individual crystals growing

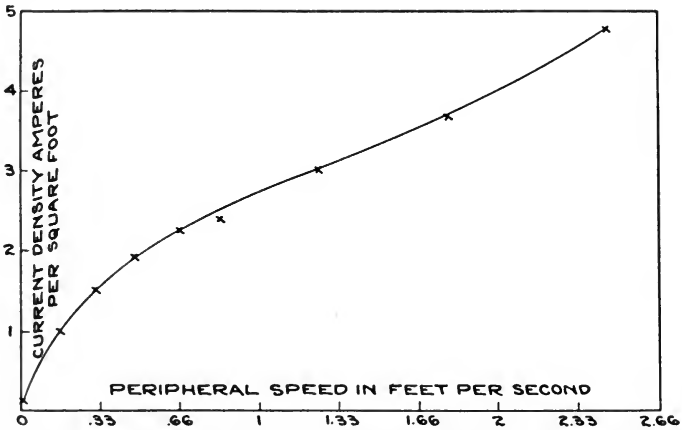

FIG. 2. Showing relation between permissible current and surface velocity.

next to one another over the surface. The individuals do not all present the same crystal faces to the solution—some offer fast growing surfaces, others slow growing surfaces. There results a matted deposit which soon harbors crevices in which stagnation can occur; sulfide is liberated, and the surface becomes dull and powdery.

Crystalline deposition has long been the enemy of the practical plater,[12] and in the effort to combat the trouble he has accumulated a list of "doctors" and addition agents[13] which, added in relatively small quantities, greatly diminish granularity. Of the well-known "doctors," glue, gum arabic, tannin, carbon bisulfide, fluorides, silicates, *etc.*, glue, and gelatin[14] are the most powerful. Photo-

graphic hypo contains a little true gelatin and always much degraded gelatin having the properties of glue. The fixing bath thus contains its own "doctor."

It should be explained that gelatin is an "amphoteric" colloid[15] whose particles can behave in solution as though positively or negatively electrified, according to the acidity or alkalinity prevailing. In an acid fixing bath the gelatin "ion" moves to the cathode and is *deposited with the silver*, the properties and appearance of which it modifies profoundly.* When the solution holds traces of gelatin the deposit is firm and adherent, and varies from a creamy white matte surface to a pure white burnished surface of extreme brilliancy. As the gelatin products are increased the deposit becomes bluish-white with a brilliant specular reflection. Analysis reveals 99 to 96 per cent of silver and 1 to 4 per cent of gelatin and water. The mechanical strength is poor, and the contraction on drying is often sufficient to strip the metal from the cathode. Further increases in gelatin yield dark blue or black deposits greatly contaminated with sulfide, and when this happens the hypo solution becomes badly discolored.

A guess at the underlying causes of these changes is helpful. It is supposed that a small addition of gelatin allows a thin layer of relatively large spongy gelatin molecules (micellae) to adhere evenly over the initial deposit of silver. The layer is thin enough to be electrolytically conducting, and thick enough to repress the faster growing crystal faces and to force the next layer of silver to deposit uniformly. Probably the idea of alternating layers of silver and gelatin is merely a useful fiction, the true reaction being an indiscriminate absorption of gelatin with the silver, which prevents the development of any but the most isolated fragments of crystal lattice. When the gelatin content is high the adsorbed layer is so thick that it imprisons a volume of hypo solution from which the silver thiosulfate ions are being depleted by migrating, and the evil condition of substantially no agitation is produced.

In motion picture practice the gelatin in the fixing bath varies all the way from a just sufficient quantity for good plating to a serious overload, and it becomes imperative to learn to control plating whatever the condition of the bath.

The search for a gelatin antidote or plating "activator"[16] brought

* It is supposed throughout these descriptions of plating surfaces that the solution is correctly adjusted, well agitated, and electrolyzed at a suitable current density.

to light a very interesting series of compounds, any member of which will neutralize the effect of excess gelatin and further improve the plating with moderate gelatin content. The compounds are generally organic sulfur bodies containing the active grouping

$$S = C\begin{matrix}\diagup NHX \\ \diagdown Y\end{matrix}$$

The simple compound, thiourea,

$$S = C\begin{matrix}\diagup NH_2 \\ \diagdown NH_2\end{matrix}$$

is one of the best activators. Thiocarbanilide,

$$S = C\begin{matrix}\diagup NH.C_6H_5 \\ \diagdown NH.C_6H_5\end{matrix}$$

and the *iso*-thiocyanates, such as allyl iosthiocyanate, $SCN.C_3H_5$, are also excellent. They are added in the proportion of about one part to 100,000 of solution, and they then allow higher gelatin concentrations and higher current densities to be manipulated than the bath will normally tolerate.

The function of the activators is fairly well understood. The groupings

$$=C\begin{matrix}\diagup N\langle \\ \diagdown \end{matrix} \quad \text{and} \quad = C = N—$$

are sufficiently "polar" to allow the compounds to migrate in the electric field. With an acid bath containing thiourea and gelatin, both substances move toward the cathode and compete for position on its surface. Thiourea, however, contains the grouping

$$S = C\begin{matrix}\diagup N\langle \\ \diagdown \end{matrix}$$

which has the peculiar property of inducing formation of double salts with silver halides which ultimately decompose, yielding silver sulfide.

$$S = C\begin{matrix}\diagup NH_2 \\ \diagdown NH_2\end{matrix} + AgBr \longrightarrow Br^- + Ag\text{---}S\begin{matrix}\diagup NH_2\text{---}H^+ \\ \diagdown NH_2\end{matrix}$$

The decomposition is repressed in acid solution and accelerated in alkaline solution. The acid fixing bath offers a medium in which the

thiourea can carry silver to the cathode in spite of the presence of gelatin, and can then leave most of it there as metallic silver deposited on an immense number of silver sulfide nuclei which are being laid down uniformly without reference to any existing crystal lattices. There is thus a vital interplay between gelatin and the activator, the gelatin interfering with the growth of fast growing crystal faces, and the activator seeding the surface for uniform new growth.

Old fixing baths electrolyzed in small vessels in the laboratory have always yielded better deposits with activation; large commercial electrolytic plants, such as we shall describe, do not always need the addition; and it is possible that the thiosulfate during the prolonged electrical treatment, necessitated by the large bulk of solution, generates its own activators in the form of ephemeral polythionates.

To summarize, the best plating is secured when:

(*a*) the solution contains sulfite;
(*b*) the solution contains a little free acid;
(*c*) the solution is vigorously stirred;
(*d*) the solution is continuously filtered;
(*e*) the temperature is kept low;
(*f*) the current density is kept below 3 amperes per square foot;
(*g*) there is present in a million parts of solution 10 to 1000 parts of gelatin or gelatin degradation products;
(*h*) there is present in a million parts of solution 10 to 1000 parts of an activator.

A Commercial Plating Cell.—The following ways of stirring the electrolyte have been considered:

(1) by air;
(2) by external pumps;
(3) by rotating the cathode;
(4) by rotating the anode;
(5) by rotating paddles between the anode and cathode.

(1) Of these alternatives, air stirring is by far the most attractive, and at least one commercial unit is operating successfully by this means. For the present experiments air stirring was found inefficient, the lack of efficiency being ascribed to two causes. Frist, the silver is deposited by a *secondary* reaction, in which the silver thiosulfate complex is reduced by nascent sodium or hydrogen. When the cathode is wiped by a continuous stream of air bubbles, part of the reducing material is oxidized by the air and the current efficiency falls off seriously. Secondly, the space between anode and cathode which should be occupied by the electrolyte is filled with

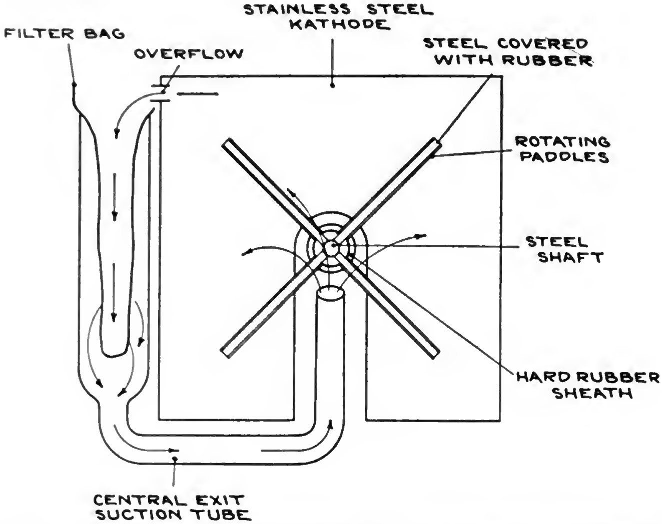

FIG. 3. Diagrammatic construction of cell showing arrangement of paddles.

bubbles so that at any moment only part of the plating area is effective.

(2) Hypo containing silver is one of the most corrosive solutions known for common metals. Stirring paddles, bearings, and pipe

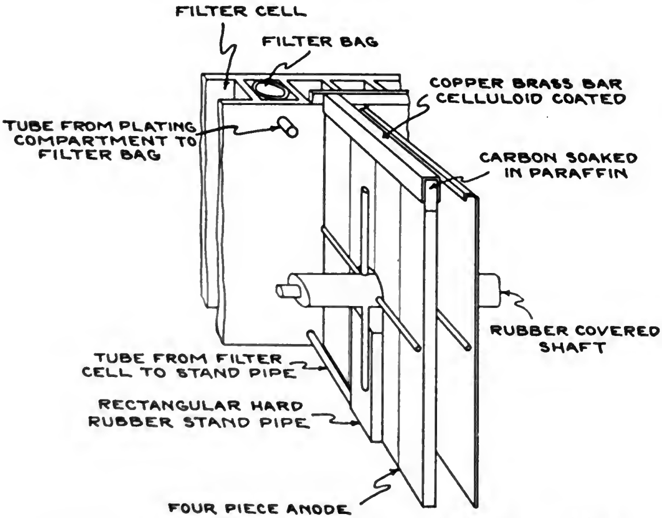

FIG. 3A. Diagrammatic construction of cells and paddles.

lines should be made of special alloys or hard rubber, and it is scarcely more trouble to incorporate these materials in an internal stirrer than in separate pumps.

(3) and (4) The rotating cathode is objectionable because the shaft must be dismantled for stripping the silver. The rotating anode is good except that heavy electric currents have to be conveyed through slip rings to the shaft, and thence by good connections to the anodes which are conveniently made of carbon or graphitic materials that do not lend themselves to good contact.

(5) Rotating electrodes tend to move in a smooth slip stream in

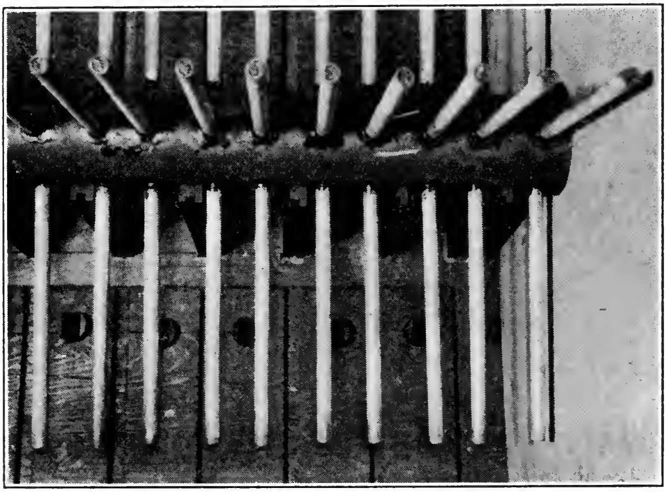

FIG. 4. Photograph showing slots, stand-pipes, paddles, and the composite anode (on the right).

which the true agitation at the cathode surface is poor. Paddles revolving between the electrodes not only swing the solution but, since they occupy volume, they disturb the diffusion strata as they pass each element of the plates. Paddles are adopted in the present design.

Construction of Cell.—The plating cell is a wooden box housing a number of unit compartments consisting of an anode and a cathode, slotted to straddle a shaft. The complete cell comprises 13 compartments containing 26 paddles of four blades each, 13 cathodes of Allegheny metal, and 14 anodes of graphite. Fig. 3 and Fig. 3A show the construction diagrammatically. The four-piece graphite

anodes have an arch cut into the center sections and may thus slip down over the shaft. They are held vertically by slots cut in the walls of the cell, and the center arch engages with rectangular hard-rubber stand-pipes which project from the bottom of the box at regular intervals. The slots, stand-pipes, and paddles, and one composite anode (seen to the right) are shown in the photograph, Fig. 4.

The body of the cell (Fig. 5) is made of cypress, impregnated with paraffin. The outside dimensions are 36 in. wide, 35 in. deep, 55 in. long; with over-all dimensions of cell, stand, and shafting, 36 in. wide, 43 in. deep, 79 in. long. The ends of the box are slotted to receive

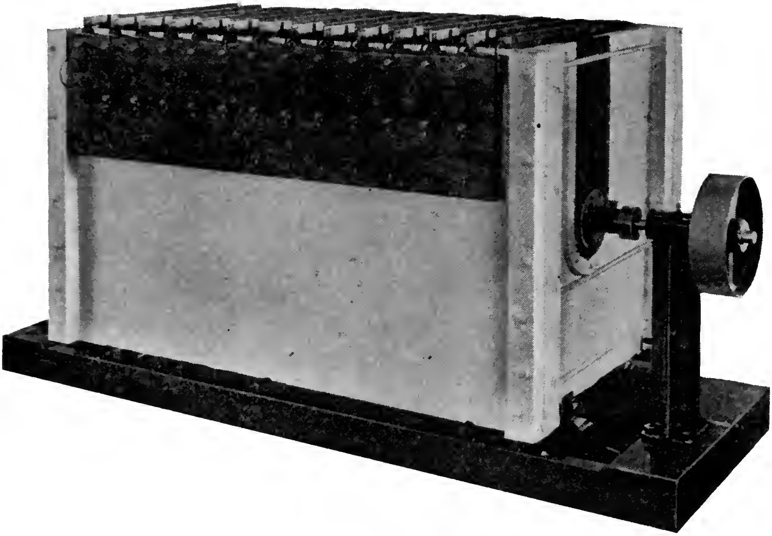

FIG. 5. The complete cell.

the shaft, and are covered with flexible rubberized canvas to which part of the bearing arrangements are secured. On one side of the cell is a simple panel board (Fig. 6), on which are assembled clips for making contact with the cathodes. The clips are connected in series with adjustable coils of resistance wire with copper wire shunts by means of which the current flowing to each plate may be measured by a millivoltmeter, and with a bus-bar lying behind the board. The anodes are connected by insulated leads to a second bus bar. On the other side of the cell are situated the tall, rectangular filter boxes, in each of which is a felt bag. As the paddles rotate, a negative pressure is developed by centrifugal force in the neighborhood of the

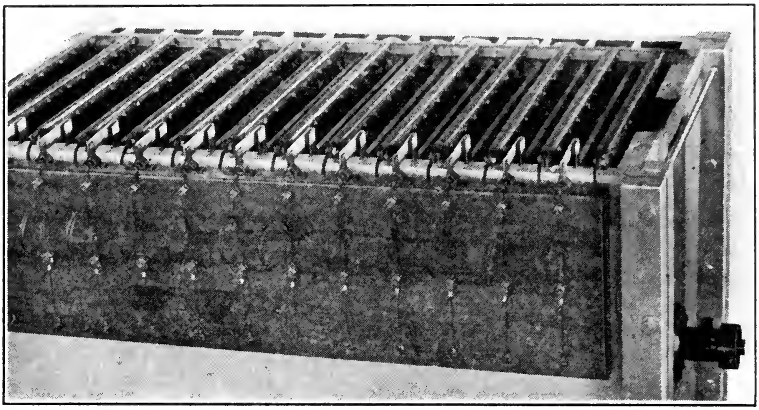

FIG. 6. Panel board of the cell.

shaft. Liquid is sucked in through the stand-pipes from the filter boxes until the liquid level in the latter has fallen to such an extent as to balance the suction. The solution overflows from the compartments through short pipes placed near the top into the filter bags, whence it returns to the compartments by way of the stand-pipes.

Filtering is not the only useful purpose to which the centrifugal action of the paddles has been put. The spaces at either end of the box beyond the outside anodes have no paddles, and the level in

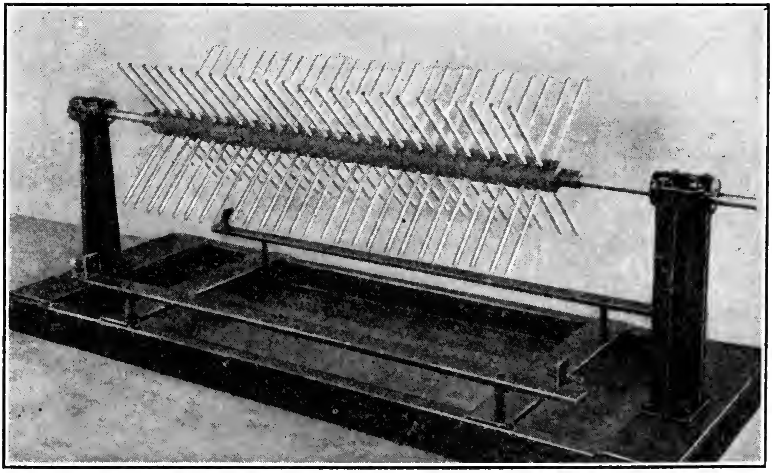

FIG. 7. The complete shaft and paddle assembly.

these spaces is lower than in the plating compartments. It is therefore convenient to connect a number of cells in series, allowing the solution to enter at a low level compartment and leave at a high level. The cells do not have to be staggered to induce flow from one to another.

The Shaft and Bearings.—The shaft is of stainless steel, thicker in the middle than at the ends. At intervals along the thick portion, steel collars with four threaded holes are placed, the hard-rubber protecting tube is thrust in place, and the paddles are screwed into the collars. The paddles are protected with soft-rubber tubing blocked with mastic at the top. Each end of the wide portion of the

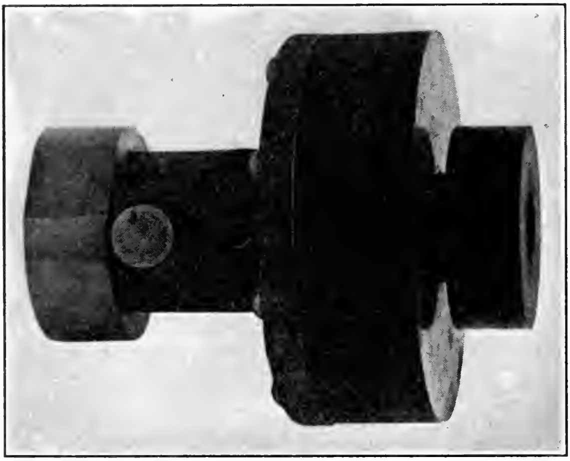

FIG. 8. The false bearings.

shaft is covered with a rubber boss which rotates with about 0.003-inch clearance in a rubber collar bolted to a brass stuffing-box. The collar and stuffing-box float on the shaft, and are screwed to the ends of the cell by a flexible rubber gasket. A small tube conveys a trickle of water into the space between the rubber boss and the collar, which effectively prevents hypo from working back to the naked shaft. The true bearings are located outside the cell on stout supports. The whole assembly is mounted on an angle-iron base with suitable provision for adjusting the cell box relative to the shaft. The shaft is shown in Fig. 7, the false bearings in Fig. 8, and the whole assembly in Fig. 9. The shaft is rotated at about 80 rpm., requiring about $^1/_2$ hp.

Performance.—The rate at which silver can be deposited is proportional to the quantity of silver in the immediate vicinity of the cathodes. This is influenced by the silver content of the solution and the rate of stirring. As the content is lowered during passage through the cell the permissible current diminishes, and it is consequently necessary to stagger the input from plate to plate. While the first few plates have been known to take as much as 30 amperes each, the last may require as little as five. The adjustment is made by altering the length of the resistance wire connecting each plate. With a

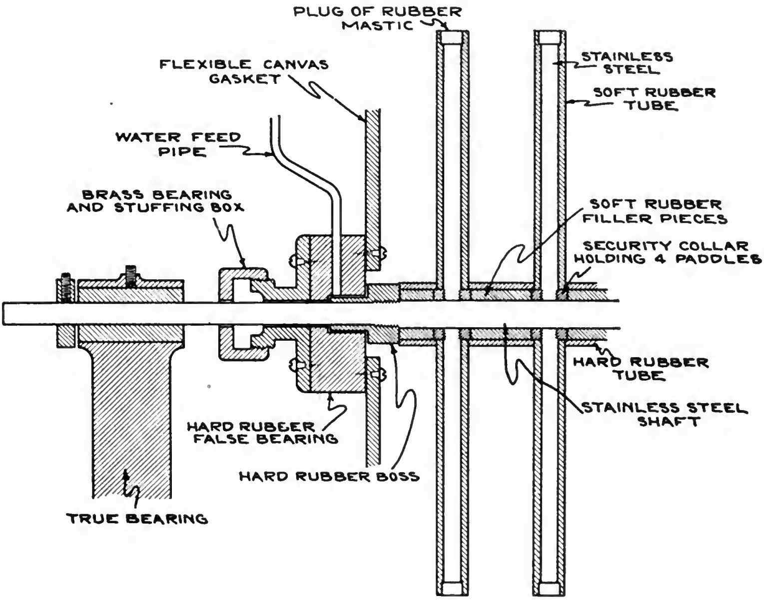

FIG. 9. The complete assembly of shaft and bearings.

stirring speed of 80 rpm. and an acid hypo bath of approximately the following initial composition:

Hypo	300 parts
Sodium sulfite	10 parts
Acetic acid (or the equivalent)	10 parts
Chrome alum	10 parts
Silver (metal)	4 parts
Gelatin, developer sludge, *etc.*, amount equiv. to 200 ft. of film per gallon	
Water	1000 parts

a current of from 200 to 250 amperes may be employed to reduce the silver content to 1 part per 1000. This will reclaim hypo from about 10,000 feet of positive film per hour.

Care and Maintenance.—The cell should be kept full of hypo solution or water at all times. When containing hypo, the drip-water feed should be continued day and night whether the shaft is stationary or rotating. The shaft and bearings give no trouble during long periods if the water feed is kept running, and the stuffing-box is well packed with oiled filler.

The anodes are to be removed only in case of breakdown. The copper bus-bars at the top of each graphite assembly should be kept free from hypo deposits and should be washed frequently and given a coating of cellulose lacquer once a week. On replacing anodes after removal, the stand-pipes should be engaged very gently.

The Cathodes.—On the care of these elements and the filter bags the success of the machine largely depends. Stainless steel is used to receive the silver because of its stability toward hypo, its strength, and the difficulty with which adherent silver deposits are obtained. This property provides for ease of stripping. The electrodes should be cleaned with soap powder, rinsed thoroughly, dried, and polished with a rag moistened with gasoline containing a trace of heavy oil. They are then placed in the cell, which should be full of hypo containing at least one part of silver per thousand parts of solution. Electrolysis may be commenced at 100 amperes, increasing the current after an hour if the deposit appears bright. When at any time an over-supply of current dulls the electrodes, the current should be reduced to from 50 to 100 amperes, and allowed to remain at that value until the surface has become bright again. If the surface persists in remaining rough and dull, the electrodes should be withdrawn and cleaned with soap powder and returned for replating. Occasionally, a serious overdose of current is given to a bath almost depleted of silver, causing blackening of the electrodes and the simultaneous production of brown hypo. The current should be reduced to from 10 to 20 amperes, the hypo shut off, and the shaft allowed to rotate until practically all the color has been removed by the filters. If the cathodes now appear smooth, the flow of solution and current may be increased until the plating is proceeding normally. The longer the cathode surfaces can be maintained bright the thicker the deposit that can be built up without the labor of cleaning.

The filter bags occasionally become clogged with impurities in the hypo when it reaches the cells, and with silver sulfide sometimes generated during plating. When it is apparent that little filtering is taking place, the bags should be withdrawn, turned inside out, and rubbed vigorously under the surface of water standing in a large crock. They should then be whitish in appearance and free of loose deposit, and may be returned to the cells in the inside-out condition. At the next washing they will again be reversed.

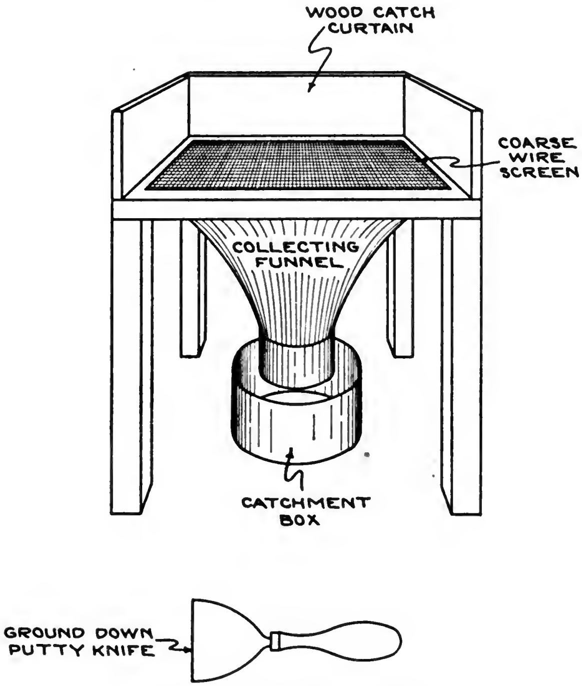

FIG. 10. The stripping table.

The brown sludge from the filters is allowed to settle and is occasionally drawn off from the bottom of the crock, dried in shallow pans, and sold to the refiners. Alternatively, it may be dissolved in nitric acid, reprecipitated with sodium carbonate, redissolved in hypo, and electrolyzed. The quantity of this sludge relative to the total silver handled is very small.

Stripping the Cathodes.—In general, the lower the current density used for plating, the smaller the gelatin content of the silver deposit.

In the present process, the current density is usually high, and the deposit is a composite material which contracts on drying. To remove the silver the electrodes are washed, dried with or without gentle heat, and placed on a stripping table (Fig. 10). Gentle bending or tapping detaches part of the silver and the remainder is pried off with a ground down putty knife. The stripped electrode is wiped with gasoline as in the first instance, and replaced in the cell.

The Silver.—Baths containing much silver and sulfite and acid have yielded deposits which, when dried in an oven, gave the following analyses:

	Per Cent
Silver	99.7
Chromium	.1
Gelatin and water	.2
Other metals	A trace

From baths rich in chrome alum and developer residues which have been contaminated by passing through much piping and metal tanks, the following is a typical analysis of silver obtained with a current of 300 amperes per cell.

	Per Cent
Silver	94.3
Gelatin and water	4.1
Copper	.3
Chromium and iron	1.0
Ash	.3

Of these constituents, the silver is freed of all but the copper by simple ignition in the presence of air. Refining charges, in the usual sense, need not be contemplated. The copper can be removed at the source by careful attention to the layout of the piping and tanks in the processing laboratory.

ELECTROLYTIC RECOVERY IN THE PROCESSING LABORATORY

The General Method.—It would seem that the simplest way to employ the electrolytic cell is to fill it with silver-bearing hypo, apply a maximum current, and gradually diminish the input in step with the depletion of silver. If half the silver is removed in X minutes, and half the remaining silver in the next X minutes, *etc.*, it will be a very long time, indeed, before all the metal is gone. Practically, the last traces leave more hurriedly than indicated by the exponential scale, but even so the scheme demands periodic analyses

to control the plating current. The intermittent method is not recommended.

With a continuous flow of solution through the cell, plating is conducted very efficiently when only a partial removal of the silver is desired. It is apparent that if X compartments are required to reduce the content to one-half the original content, $2X$ compartments will be needed to carry the silver to $^1/_4$, $3X$ to $^1/_8$, and so on. In removing 99 per cent of the silver X compartments will remove 50 per cent, whereas it requires $5X$ to remove the next 49 per cent.

The solution is handled most economically by dividing the plating cells (or compartments in a small installation) into two groups. The first group handles the main bulk of the fixing bath in a rapid, continuous flow. Although hitherto commercial hypo has been used until it contains 5 to 8 grams of silver per liter, it is now not allowed to accumulate above 2 or 3 g., and is passed through the cells where the content is reduced to $^3/_4$ g. The second group of cells receives a small portion of the total solution, from which it removes all the silver before allowing it to pass to waste. The economy achieved can be illustrated by studying the case where a certain quantity of hypo is circulated, say, three times through the first group of cells before it is discarded the fourth time through the tailing cells. The quantity of silver removed by the first group will be $3X(2^3/_4 - {}^3/_4)$ g. $= 6X$ g., while that removed by the second group will be $^3/_4X$ g. Eight times as much silver will be removed at high-efficiency plating as will be left for low-efficiency tailing.

The installation will thus consist of *working cells* and *tailing cells.* It can operate *intermittently* under constant flow with an approximately constant setting of the plating dynamo, or it can operate *continuously*, the current being varied from moment to moment to suit the volume and the silver content of the bath. In the first case, the hypo is allowed to flow from the processing machines through a filter to a tank of from 500 to 1000 gallons capacity containing a float valve which allows the solution to accumulate to a certain level, after which cocks are opened, the cell shafts rotated, and the dynamo started automatically. When the tank is empty the installation shuts down until hypo again accumulates to the high level. This scheme is simple but is reliable only when the silver content remains constant from day to day.

The continuous-flow system offers many advantages and is now installed in two processing laboratories in Hollywood. It is with

the description of the larger of these units that the paper will conclude.

The three-dimensional layout of Fig. 11 shows the arrangements in skeleton form. *A-A* and *B-B* are banks of developing machines, positive or negative, or both, located in different parts of and, if necessary, at different levels in the building. *C* is the service tank placed at a sufficient elevation to supply hypo by gravity through the trunk line, H_{R_1}, to every machine. The solution is admitted to the fixing tanks for quick filling by the valves, V_1, and for service

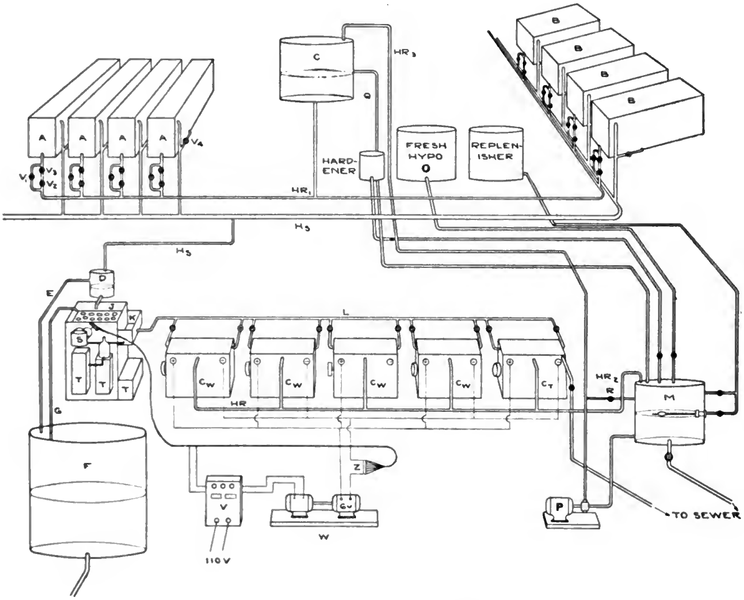

FIG. 11. Commercial recovery layout.

through the graduated valves, V_2, in series with the shut-off cocks, V_3. Hypo overflows from the machines or is dumped by valves V_4 into the trunk line, H_S, whence it flows into the spill tank, *D*, which can just accommodate the quantities of solution used at peak load. Hypo suddenly dumped reaches *D* by the same trunk line, H_S, but instead of flooding the plating cells, it overflows by pipe, *E*, into the dump tank, *F*, when it can be discarded to the drain or pumped up at leisure by the air lift, *G*, to the filter box, *J*. All hypo to be plated passes through the filter, which consists conveniently of 30 to 60

socks of felt 3 inches in diameter by 4 feet long. Thence, the solution passes through the flow-meter weir, K, into the weir box and thence by the manifold, L, into the working cells, C_W, and tailing cells C_T. Hypo from cells C_W passes into the manifold, H_R, and thence to the replenishing tank. A float valve M controls the entrance of fresh hypo from tank O to replace solution rejected to the sewer after electrolysis in C_T. The regenerated and compensated solution is pumped by the hard-rubber centrifugal pump, P, through the line H_{R_3}, back to C, where any excess returns down the companion line Q to the replenishing tank. There is thus only one pump in the system, and this operates on nearly desilvered hypo. When the operator finds the laboratory is operating under reduced load for long periods he can open the by-pass, R, until only a safe minimum is seen to return from above.

Hypo passing through the plating cells does not change in appearance except to become entirely free of suspended matter, and the progress of electrolysis can be controlled only by analysis. Since the fixing power is diminished directly with the increase in silver, and since the maximum permissible plating current varies in the same manner, it becomes vitally necessary to have reliable analytical information available at all times. Rather than leave this to human agency it has been decided to make the analysis and current control entirely automatic. The machinery devised for the purpose is described in a companion paper to the present communication, published elsewhere in this issue of the JOURNAL. It is sufficient here to say that information is desired continuously (a) on the silver content of the solution, (b) on the volume of the solution, and the information should be available as an impulse (A and B, Fig. 11) to operate the control (C) continuously.

The volume recorder is indicated in the drawing (Fig. 11) at S, and the silver analyzer at T. The composite directive impulse is communicated to the motor-controlled field rheostat, V, which adjusts the current output of the motor generator, W. The plating current is tapped at the multiple shunt, Z, from which it communicates an impulse to the devices, S and T, assuring them that their behests have been obeyed.

Operation.—A unit comprising two working cells and one tailing cell has been operating intermittently under plant conditions at Kodak Park, Rochester, for some months past on fixing solutions considerably more difficult to handle than laboratory hypo. Al-

though many set-backs incidental to the starting of the new process have been encountered the recovered silver has been of excellent quality. It is as yet too early to state the number of times the hypo can be used again, or what should be the nature of the replenishing solutions. The exact method of procedure must be reserved for a later paper.

Fairly close cost figures can, however, be given for constructing and installing a unit to handle 100,000,000 ft. of 35-mm. film per annum.

The operating cost, calculated as an increase over probable present expenses (allowing 20 per cent per annum for interest and depreciation on capital expenditure) may be computed as follows:

To capital expenditure	$3000
Renewable materials, electric current, smelters' charges, *etc.*	1500
To increased labor and part-time skilled supervision	2000
	$6500

The savings to be expected cannot be determined exactly at this stage. Analyses of samples of various brands of film have shown that somewhere between 1500 and 1700 ounces of silver should find their way into the hypo from each million feet processed.* It has not been possible to survey the recovery statistics from many laboratories but figures ranging from 800 ounces to 1200 ounces have been reported. It is fair to assume that 1100 ounces will provide a conservative figure for computing the present savings.

The discrepancy between 1100 ounces recovered and from 1500 to 1700 ounces recoverable can be ascribed to various causes of which "carry-over" of hypo into the wash water is the most important. Whatever process is now used for recovery, the yields could be increased if the general practice were adopted of placing a squeegee before and after the fixing baths. Further increased yields will be obtained by continuously removing silver from the hypo during use so that the fixing solution carried away will contain little precious metal.

For the present purpose it will be assumed that the recovery can be increased 250 ounces per million feet of film; that the hypo can be used at least twice; and that refining charges can be lowered from 6** to 1 per cent of the total value of silver recovered. The saving account will read somewhat as follows:

* 25 per cent negative; 75 per cent positive and sound track.

** Figures as high as 10 per cent are reported.

To increased silver 20,000 ozs. per annum at 30¢ per oz.	$ 7,500
To decrease in cost of fixing bath, hypo at $2^1/_2$¢ per lb.	6,500
To credit on refining charges at 5 per cent of $39,000	1,950
Gross saving	$15,950
Less operating charges	6,500
Net annual saving	$ 9,450

The figures quoted above are minimum amounts. Silver is likely to bring more than 30 cents an ounce. The fixing bath can probably be used more than twice before discarding and there remains the probability of further increased silver yields. If at any time the plant were increased in size the operating charges would remain substantially unaltered save for the installation of extra cells. Finally, the electrolytic method offers in place of the dirty and malodorous sulfide precipitation, a process free from smell, which can be operated with the cleanliness and precision of a dairy. The fixing solution, instead of passing progressively from a fresh to a stale condition, remains clear, filtered, and possessed of uniform fixing and hardening properties.

The authors are glad to acknowledge that these experiments are the coöperative effort of many members of the Research Laboratory and engineering staff of the Eastman Kodak Company.

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AUTOMATIC SILVER RECOVERY CONTROL*

K. HICKMAN**

Summary.—*In using the system for electrolytically regenerating fixing baths described elsewhere in this issue of the* JOURNAL, *it is evident that a very exact relation must subsist between the quantity of film fixed and the current supplied for electrolysis. If the current decreases the solution will become overburdened; if the current is too great decomposition will occur owing to lack of silver for plating. A monitoring system has been developed in which the solution is analyzed periodically by an optical titrating device. Measured quantities of the fixing solution and sodium sulfide are mixed, forming a brown suspension which is inspected by a standard lamp and a nickel wire bolometer. The indication is interpreted by a master relay which actuates a motor-operated field control on the plating dynamo. While the monitor works efficiently, it has been found that the lag in increase or diminution of silver in large processing plants is so great that hand adjustments, made after casual inspection two or three times a day secure sufficiently accurate plating. The automatic shows its greatest utility in shutting down the apparatus at night when there is no personal attention available.*

Silver thiosulfate electroplating processes require rigid control[1] of the plating current to secure efficiency and freedom from occasional failure.

The maximum safe current is determined by the product of three variables: the silver concentration of the solution, the rate of flow of the solution through the apparatus, and the "plating capacity" of the apparatus.† In a permanent installation the "capacity" of each cell is determined once for all, and this variable then becomes a constant; it remains necessary to devise machinery for determining the other two factors at frequent intervals, or continuously, during operation. The machinery comprises a silver concentration monitor, a flow monitor, an electric mixing panel with indicating instruments

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** Kodak Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

† The plating capacity is itself a composite of a number of variables such as degree of agitation, shape, size, and nature of the electrodes, but a particular design of cell operated at a given stirring rate has a constant capacity.

and a contacting galvanometer, a metering shunt in the plating circuit, and a motor-operated rheostat controlled from the mixing panel.

The Silver Monitor.—The methods of determining silver content which make the most obvious appeal have not proved the most feasible in the author's hands. They will be described briefly, to clear the ground for future experimenters.

Conductivity.—A typical used fixing bath contains

Hypo	300 parts
Sodium sulfite	10 parts
Alum	20 parts
Acid	5 parts
Silver halide	10 parts
Water	1000 parts

The constituents may be divided roughly into: silver conducting salts, 1 part; other conducting salts, 30 parts Although the silver salt is a better conductor than hypo, it reaches a maximum concentration of less than 4 per cent of the latter, and does not influence the total conduction by more than 10 per cent. Variations in compounding the bath from batch to batch, variations in developer contamination, and aging are liable to affect the conductivity more than variations in silver content.

The Silver Electrode Potential.—When silver electrodes are placed in two vessels containing identical hypo solutions, the vessels being connected by a liquid bridge, no potential difference is observable between the two poles. Addition of a soluble silver salt to one vessel develops an emf., the difference of potential between the two silver plates yielding an exact indication of the quantity of silver present. Although it would be simple to provide a standard solution in one half-cell, unless the hypo concentration in the fixing bath flowing through the other half-cell remained constant the apparent silver potential would vary because the quantity of free silver ion is as dependent on the quantity of hypo present as it is on the quantity of silver bromide.

The difficulty may be avoided if the fixing bath is passed into the first half-cell, and thence into the second half-cell by way of a plating chamber where all the silver is removed. The same hypo is thus used in each half-cell and the potential difference between the two compartments should be due to the silver content alone. To test the assumption the triple cell was built, shown in Fig. 1. Processing hypo is sampled continuously in two drip-feed streams. Stream

A passes into cell A_1 and immerses the silver electrode, P_{Ag}. Stream B flows into cell B_1, where it is electrolyzed between rotating electrodes and allowed to pass thence, free of silver, into the cell, B_2, where it immerses the silver electrode, P. The slow streams from A_1 and B_2 meet at J, providing the necessary liquid junction, and overflow at J_1.

The limitations of this method, which appears so promising, are written in the graphs of Fig. 2 and Fig. 2A. It is seen that a small

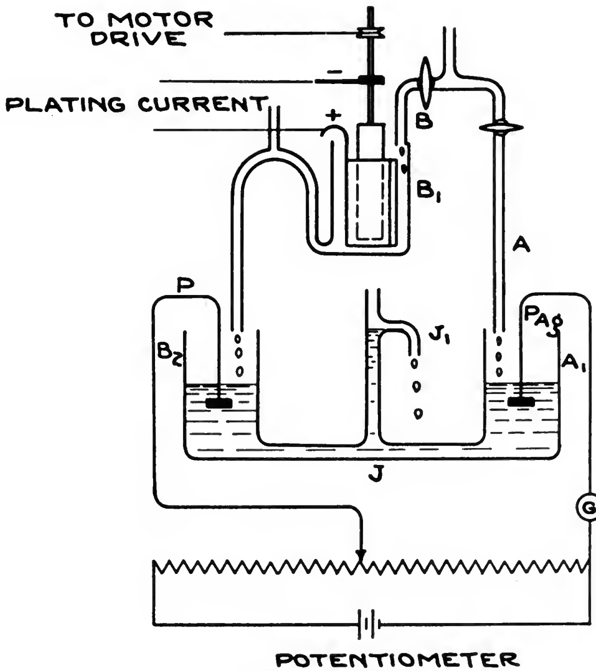

FIG. 1. Silver potential meter.

difference of potential is produced the moment electrolysis starts, which reaches a high steady value after a few minutes. Unfortunately, a nearly similar difference of potential is produced when fixing bath containing *no* silver is electrolyzed, owing to the generation of reducing materials which alter the solution pressure at the second electrode. Fig. 2A reveals that the difference between hypo containing silver and hypo free of silver is also dependent on the surface condition of the silver electrodes. The potential indicators were thus of no present value.

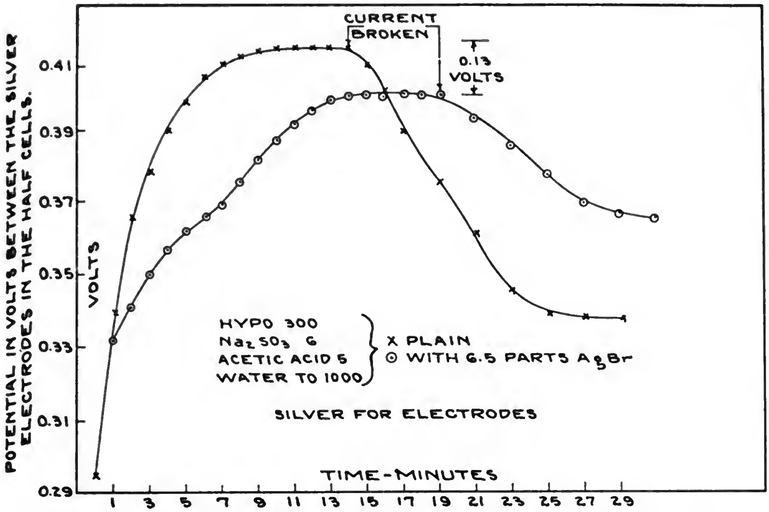

FIG. 2. Relation between voltage developed in half-cells with time.

The Plated-Wire Bridge.—The throwing power of silver thiosulfate solutions is so great that small cathodes in uniformly stirred solutions build up adherent deposits at a rate which can be made to vary directly with the silver content. If the cathode is in the form of a very fine resistance wire its conductivity increases during unit

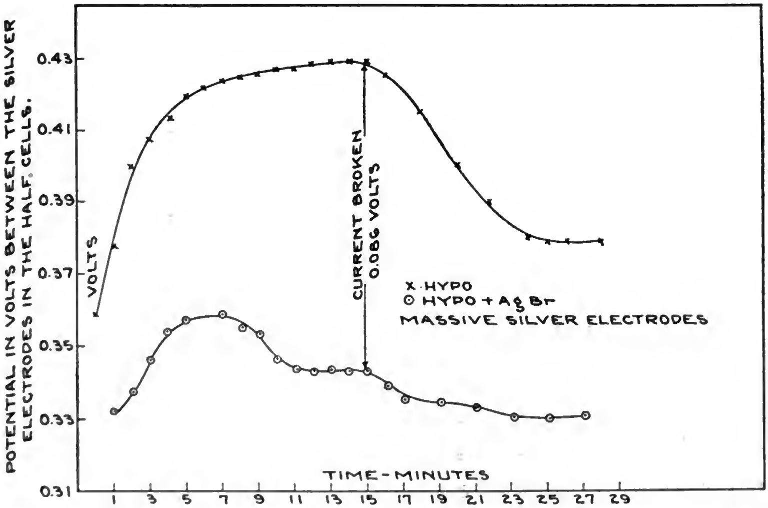

FIG. 2A. Showing the effect of the surface conditions of the electrodes on the voltage developed in the half-cells.

exposure to the solution in a degree proportional to the silver content. This is shown diagrammatically in Fig. 3, where a fine nichrome wire cathode wound on a bobbin, N, is pulled at the rate of an inch or two a minute through a vessel, A, containing fixing solution, by the miniature telechron motor, T. The silver coating acquired causes a decrease of conductivity which is measured continuously in the region R_{Ag} between the two contacts C_1, C_2, connected with a conventional Wheatstone bridge. According to the degree of plating, various out-of-balance currents are recorded by the galvanometer. The electrical indications produced are accurate and of an order large enough

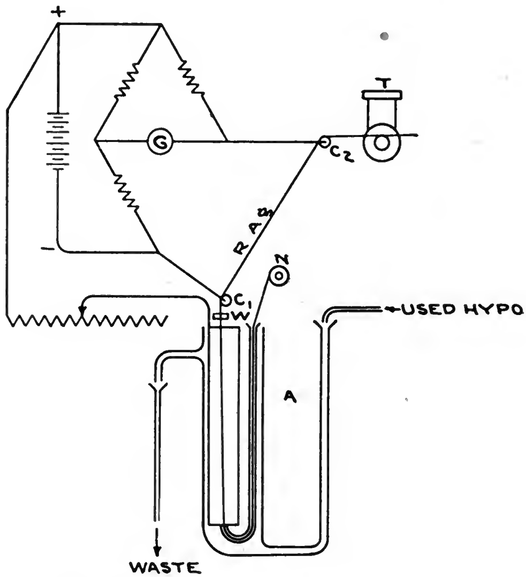

FIG. 3. Resistance wire plating meter.

to actuate robust relays. The method was abandoned in favor of the one described next merely because the development of the colorimetric apparatus happened to be more advanced when its use was urgently required.

The Silver Sulfide Colorimeter.—Sheppard[2] and Hickman[3] have shown that the optical covering power of colloidal silver sulfide solutions can be duplicated with accuracy if the conditions of precipitation and the age of the solution at the time of viewing are kept uniform. The conditions are simple, involving little more than rapid mixing in the presence of a little gelatin and standard quantities of

electrolyte. Both materials are provided sufficiently accurately by the fixing bath itself.

The automatic analytical process involves the mixture of predetermined volumes of water, fixing bath, and sodium sulfide solutions. Calibrated jets delivering a few drops a minute are unreliable[4] and it is better to use a titrating siphon[5] which three years of continuous and varied industrial uses have shown to remain accurate to within 1 per cent. The present adaptation is shown in Fig. 4 and in Fig. 5, where the siphon and accessories are assembled in a wooden cabinet. A stream of water enters the cabinet at A and flows to waste at A', A''. A constant level is maintained above the stop-cock, B, which allows a small and approximately uniform trickle to fill the bulb, C, which overflows when the level reaches the neck, yielding a unit volume of water with great precision from time to time. Owing to the inability of individual elements in the continuous fluid stream to accelerate normally under gravity, a powerful suction is developed at the calibrated jets, S and Ag, causing unit quantities of sodium sulfide solution and hypo to be drawn in at each flush. The function of the siphon is thus to convert three small continuous streams, which could not readily be metered, into three momentary streams of considerable cross-section. The sulfide and hypo are presented to the siphon from constant-level devices of well understood design. The brown silver sulfide solution which has been thoroughly mixed in the catchment vessel is now passed to the optical analyzer.

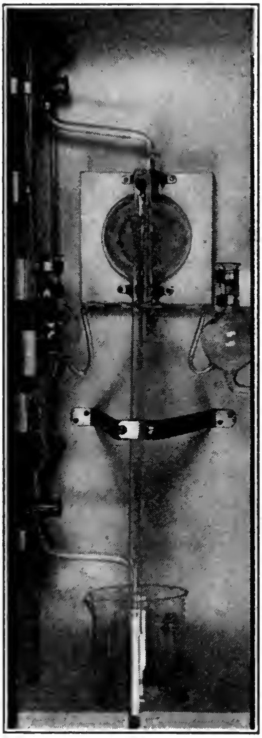

FIG. 4. Titrating siphon mounted in cabinet.

The Analyzer.—The thermopile, the cuprox cell, the selenium cell, or the photoelectric cell can serve as a suitable electric eye to observe the sulfide, but will not yield unaided the abundant power available from the nickel resistance bolometer. The thermopile, under the influence of radiation which is poor in infra-red rays, yields small currents from a low impedance circuit which are difficult to amplify.

The cuprox cell requires regular rest periods.

The selenium cell yields a square-law response curve which can be made to parallel the opacity-silver content curve, and it is this type of detector which may later be used.

The photoelectric cell yields unidirectional currents which are not conveniently utilized in the simple resistance networks at present employed in the control mechanism.

THE SILVER ANALYZER

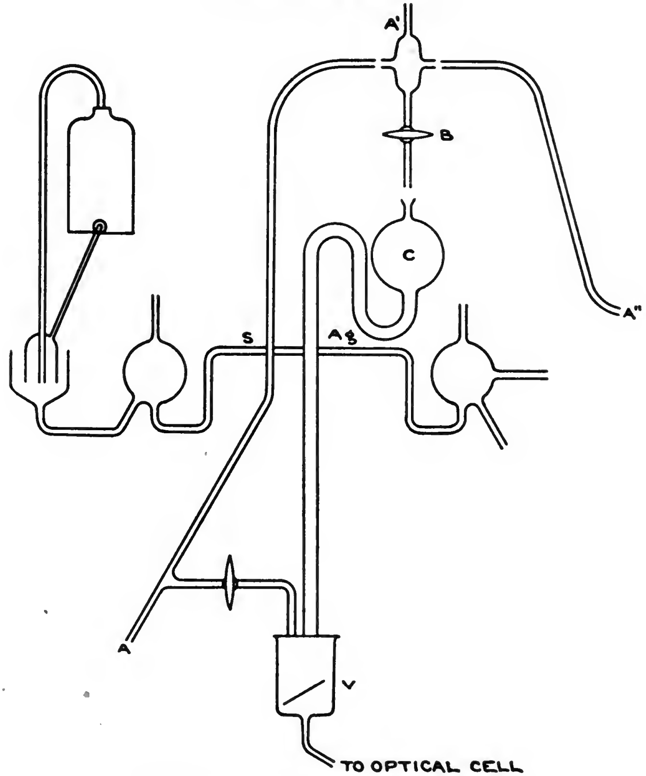

FIG. 5. Schematic of titrating siphon.

The Nickel Resistance Bolometer.—The well-known bolometer or radiation type of resistance thermometer depends for its action on the large increase of resistance exhibited by certain metals, notably pure nickel, when warmed, the resistance doubling with a change of temperature of from 0°C. to 180°C. Usually two identical elements are employed in the opposing arms of a Wheatstone bridge, one ele-

ment receiving the radiation, the other compensating for changes of room temperature. The receiving element generally comprises a single strand of exceedingly thin foil which, however, demands the passage of large currents at low potential.

For the present purpose a resistance of at least 100 ohms per element is desirable,* and a special bolometer has been constructed which yields comparatively large out-of-balance potentials. No. 40 pure nickel wire is given a thin, transparent coating of bakelite varnish and is then wound into a 90-degree cone until a resistance of from 150 to 160 ohms has been obtained. It is then varnished with cellulose acetate dissolved in a solvent which does not soften the bakelite, is allowed to dry, and is stripped from the support. Two of these feather-weight cones are mounted in a triangular glass support and the assembly is placed within a glass globe having a mica window to eliminate drafts.

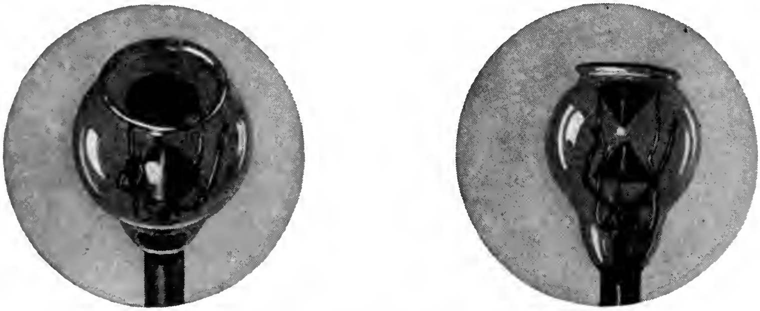

FIG. 6. The nickel resistance bolometer.

The cones occupy two arms of a Wheatstone bridge, the other two conveniently being two opposite sides of a 100-ohm potentiometer. A potential of from 2 to 16 volts is applied, according to the sensitivity desired, and both cones become slightly warm. Preferential illumination increases the temperature and hence the resistance of the front cone, and causes an out-of-balance current to pass through the galvanometer. In a certain light beam, a specially selected thermopile gave 3 milliamperes at 8 millivolts, whereas the nickel bolometer yielded 10 milliamperes at 180 millivolts, sufficient power to actuate a Weston contacting galvanometer when less than a 2 per cent alteration of the light intensity occurred.

* Wound in another form, nickel elements of this order are much employed in resistance variation instruments for industrial recording and in control thermometers. The "Brown" instruments are typical.

The Optical Arrangement.—This consists of a simple lamp house with a mirror and condenser directing the beam through a liquid cell onto the bolometer (Fig. 6) from a 200-watt, pre-focus, 115-volt projection lamp operated at 90 v. The assembly is mounted below the titrator from which it receives sulfide solution by gravity.

The Electrical Arrangement.—At its simplest, the current ready from the analyzer should be employed to alter the field excitation in

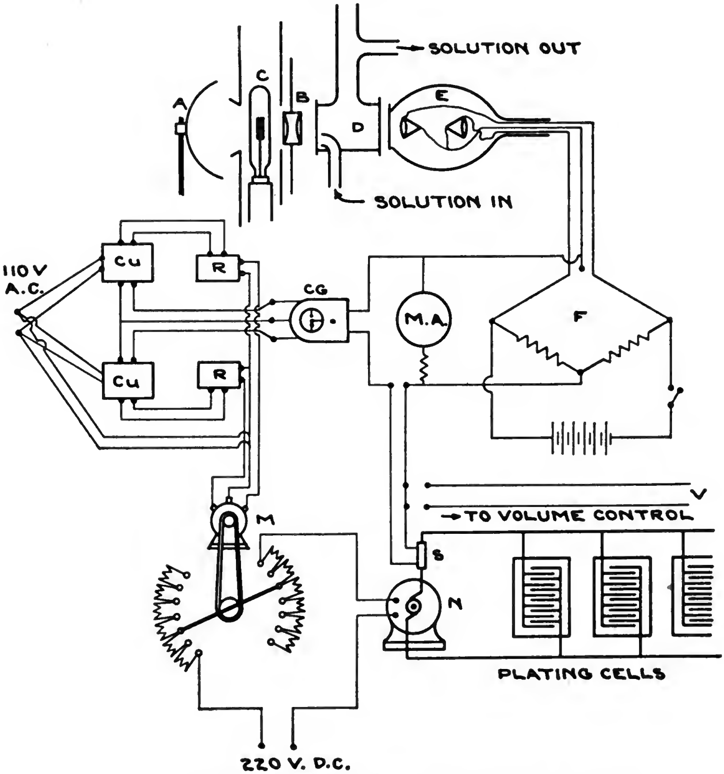

FIG. 7. Detailed schematic assembly of control systems.

the plating dynamo to yield currents suitable for the silver content of the fixing bath. This can be obtained by opposing the out-of-balance current from the bolometer by a current derived from a shunt placed in the plating circuit. The alteration of both field current and output of the plating dynamo can be accomplished by the vacuum tube (grid glow or thyratron) but in the present state of the art it is preferred to use relays and a rheostat actuated by a split-field re-

versing motor. The entire assembly, including the optical analyzer, is detailed in Fig. 7.

Referring to the general assembly (Fig. 7), the mirror, *A*, and condenser, *B*, project a beam from the lamp, *C*, through the liquid cell, *D*, onto the front cone of the bolometer, *E*, which occupies one arm of the Wheatstone bridge, *F*. The out-of-balance current is measured by the heavily shunted microammeter, *MA*, and is allowed to expend the bulk of its energy in the Weston contacting galvanometer, *CG*. The relay contacts in the galvanometer are fed by low voltage a-c. circuits tapped from two trickle-chargers, Cu ($^1/_4$ amp., cuprox).

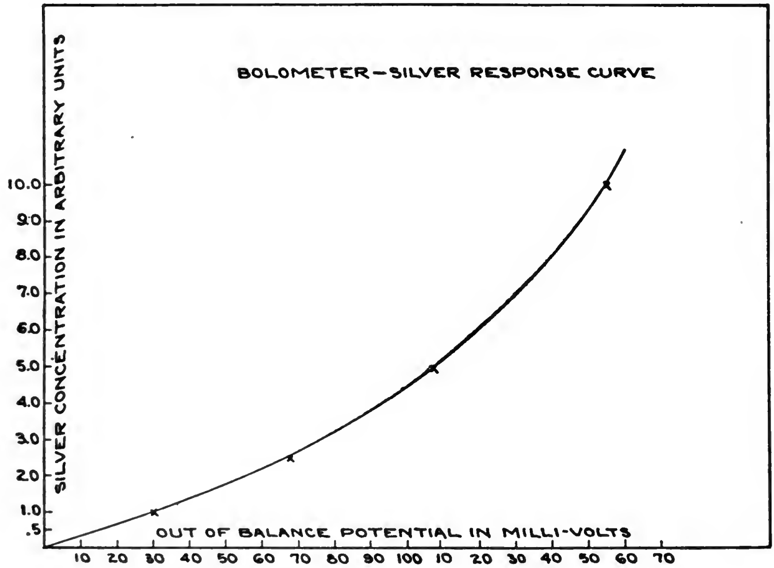

FIG. 8. Response curve of the bolometer.

Closure of one or the other of the circuits actuates either the right-hand or left-hand relay, *R*, by *direct* current causing the reversible motor, *M*, to raise or lower the output of the low-voltage motor-generator, *N*, which feeds the plating cells.

In order that the system may work quantitatively in stable equilibrium the current from the Wheatstone bridge is opposed by a current derived from the shunt, *S*, in the plating circuit. Right- or left-hand contact continues in the contacting galvanometer causing operation of the motor rheostat until the out-of-balance current has been offset by adjustment of the plating current.

It is apparent that the degree of adjustment, that is to say, the proportionality between density change in the colorimeter to current change in the plating circuit is dependent on the shape of the response curve of the bolometer and on the resistance of the shunt of the plating circuit, which provides the opposing current. The response curve, Fig. 8, is of necessity exponential in character, the out-of-balance current, from a circuit adjusted for zero deflection on full illumination, reaching a maximum with a certain density of silver sulfide solution beyond which an increase of coloring matter produces no effect. It is necessary to use the portion of the curve near the origin where it approximates a straight line. This is done by using faint

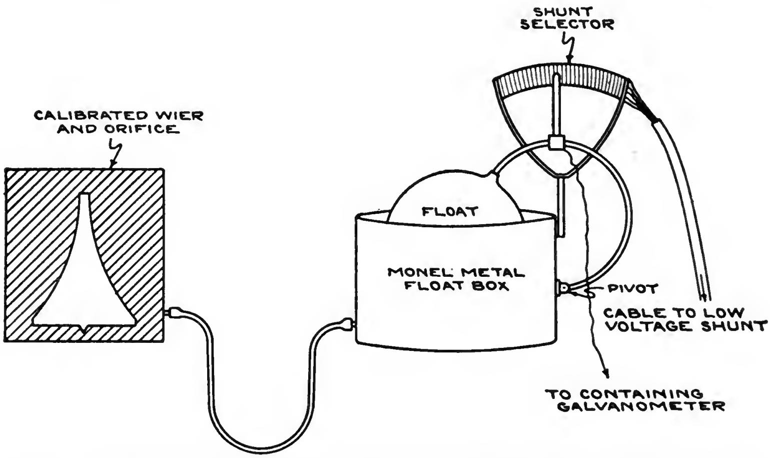

FIG. 9. Float-operated variable shunt for automatically operating volume control.

sulfide colorations and the sensitive bolometer train which has just been described.

The proportioning effect caused by varying the shunt resistance can be put to a valuable use in multiplying the silver concentration by the volume of solution handled.

The Volume Control.—There is a maximum plating current which the cells will carry for any particular silver content of the solution. It may be arranged to supply this maximum current when the flow of solution is also at its maximum; then for any smaller rates of flow at this concentration proportionally less current will be needed to deplete the bath of silver. Examples will make the point clear. Suppose hypo containing 6 grams of silver per liter is flowing at a

rate of 20 liters per minute, requiring 1500 amperes for removing 80 per cent of the metal, 1500 amperes being the maximum safe current and 20 liters per minute the greatest flow ever encountered; then, when the rate of flow falls to 10 liters per minute 750 amperes will be sufficient, and at 1 liter per minute not more than 75 amperes should be passed. Similarly, a solution containing only 2 grams per liter cannot tolerate more than 500 amperes in the same apparatus at a rate of flow of 20 liters per minute, and this must be cut to 50 amperes at 2 liters a minute.

The adjustment is automatically made by incorporating a float-operated variable shunt, such as illustrated in Fig. 9. The mechanism contains two parts, the first being a weir, cam-shaped so that the level behind the orifice rises in direct relation to the rate of flow. The weir is placed at a convenient point in the stream passing to the plating cells, and just behind the weir a tube is led to the float chamber which is just large enough to contain a hard-rubber buoy, hinged to a fulcrum on the outside of the chamber. At the top of the hinge arm an insulated spring contact wipes a number of separate copper bars, each one connected to an appropriate point in the shunt. As the level behind the weir fluctuates with variations in the rate of flow of the solution, the contact selects the appropriate potential to oppose the current generated in the silver analyzer system. Shutting off the hypo automatically shuts down the plating dynamo, and at any other position between a mere dribble and full flow a carefully chosen current is provided to regenerate the fixing bath.

Conclusion.—The apparatus described in the foregoing pages has been given no extended trial under outside commercial conditions. It has been operated successfully under the author's supervision in the Eastman plant at Kodak Park where it has proved sufficiently foolproof to need not more than occasional attention.

The author wishes to acknowledge his indebtedness to Dr. Staib and Dr. Goehler for data accumulated on the potential and conductivity relations in silver-bearing hypo solutions; to Mr. C. R. Sanford and Mr. W. Weyerts for their skill and patience in constructing much of the apparatus.

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DISCUSSION

PRESIDENT CRABTREE: Is this method applicable to hardening fixing baths containing potassium or chrome alum plus sodium sulfite and an acid? How are the hardening properties of the fixing bath maintained? Also supposing something goes wrong and you get hydrogen sulfide in the bath—is there not a chance of fogging the film in the fixing bath?

MR. HICKMAN: Those are all very important considerations and it is those points which have kept us experimenting for so long. Answering the first question, you can only electroplate solutions in which the acidity has been very carefully adjusted. We tackled the problem fundamentally and found that the optimum solutions turned out to be very similar to the usual fixing baths. You must have acid and sulfite—the more acid the better—and that also applies to the fixing bath. Most of the recent work on fixing baths has been done to find out how much acid and sulfite can be used with safety. Now, with regard to the liability of the system to go wrong; if the current is kept within safe limits the plates never spoil, and it takes an enormous excess of current to hurt the solution. When spoiling does occur it does not harm the film—only the appearance of the liquid. We have recently found an interesting thing—that the number of plates in the solution has something to do with the quality of silver depositing on a plate. We first noticed that plate No. 3 gives the best silver. The first plate does something to the solution which prepares it for the second and third plates, and since the silver content is still high at the third plate, and much of the gelatin has been taken out of the solution you can build up a very good deposit on the plates.

PRESIDENT CRABTREE: How do you maintain the hardening of the bath constant?

MR. HICKMAN: Our replenishing solution differs completely from our plating solution. It contains more hardener and a little more acid; afterward we add more alkali.

AIR CONDITIONING IN FILM LABORATORIES*

A. H. SIMONDS AND L. H. POLDERMAN**

Summary.—*A general description of the function of air conditioning apparatus in the modern film laboratory. A brief history of the development of this type of equipment, from the old rack-and-tank method of developing to the present highly developed machine methods is followed by an outline of the type and application of equipment used in the various phases connected with the progress of the film through the laboratory. Elimination of dust, accurate control of drying schedules, accurate control of temperatures and humidities in the drying cabinets and wash rooms, accurate control of developing solutions all combine to make a finished product of the highest quality every day in the year regardless of outside atmospheric conditions. A brief description of the details of the equipment is given, accompanied by pictures.*

It is interesting to note that when the production of motion pictures was beginning to assume the form of an industry in the early part of the present century, the art and practice of conditioning air was also beginning to emerge from the older, rule-of-thumb practices in heating and ventilating. During the years that have followed, many revolutionary changes have taken place in the development of these industries, as in all things mechanical.

Almost from the beginning, the air conditioning engineer has been privileged to coöperate with the motion picture engineer. Air conditioning has been applied in three distinct branches of the motion picture industry—in the laboratory; in the studio and sound stage; and finally in the theater, to provide inviting comfort for the patrons.

A paper was presented before the annual meeting of this Society in 1927,[1] outlining the problems of air conditioning in the theater, in addition to some of the features of atmospheric control in the laboratory. Few changes in theater conditioning requirements have taken place since that time except for the introduction of rather rigid demands for quietness of operation of the system and the delivery of the air, which have come about through the introduction of sound pictures.

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Carrier Engineering Corp., Newark, N. J.

Air conditioning engineers have successfully solved this sound problem; in fact, they have had to go to the extreme of limiting sound levels in the studios far below that which is required in the theater or auditorium. Therefore, we can omit further mention of the theater in this discussion, remarking only that no modern theaters are being designed today without giving consideration to complete air conditioning systems; systems capable not only of cooling in summer, but designed to maintain comfortable conditions of temperature and humidity throughout the year.

Many small theaters and some larger houses still worry along without air conditioning, taking the summer slump when it comes, putting up with a stuffy, odorous atmosphere in a crowded house during the winter. In the sound stages, the actors can, and in some places still do, sweat through their scenes under the scorching heat of the incandescents. But, in the laboratory, if we attempt to do without control, if we fail to control temperature and humidity, if we neglect to free the air from its cargo of dust and foreign matter, we meet trouble and blocked production at every turn. The subject matter of this paper will, therefore, be limited to the new developments and requirements for conditioning air in the modern film laboratory.

It is hardly necessary to remind the members of this Society of the difficulties with which the pioneers in the laboratories had to contend. Much credit is due to the men, who, in the face of adverse conditions, turned out films in those days which gave life-blood to an infant industry; and, at the same time, pointed the way for improvements, one by one, which led to the present highly efficient, almost automatic laboratory.

Look back for a moment at an interesting example, one of the early laboratories located at Bayonne, N. J., some 22 years ago. This laboratory was a converted single-story pool-room of simple frame construction with a tin roof, and was known to have habitual leaks during the rainy seasons. The entire equipment for the regulation of atmospheric conditions consisted of two coal stoves, the small one serving the so-called "dry room" and the large one the remainder of the plant. To prevent fogging of the film by the light from the stove, a large sheet-iron shield was placed around it. This stove also served as a means for heating the solution. One can well imagine the regulation obtainable with such equipment.

It was the every-day practice during the winter season to heat

the developing solution to a temperature of 70° F. and to endeavor to develop a few feet of film before the temperature dropped below 60° F. The solution cooled very rapidly because the temperature of the developing room was quite often low enough to permit ice to form on the floor; and needless to say, this in itself was quite dangerous. The developing was done in so-called trays having a capacity of about ten gallons. The developer was rocked back and forth over the film, which was wrapped on wooden racks very similar to those in use in the few laboratories that still use the rack and tank method. After the film was fixed and washed in trays of the same type as those used for developing, it was then merely hung up in the so-called dry room and allowed to dry under the best conditions obtainable in the dusty room, heated by the coal stove. The time of drying was very indefinite, to say the least, and was influenced largely by outside atmospheric conditions, varying from one-half to 24 hours.

The total capacity of this laboratory was 35,000 feet of film a week; but to attain this capacity it was necessary to work day and night, including Sundays and holidays. Today, the modern laboratory can turn out 35,000 feet of film in about 30 minutes, without being over-taxed.

Later, this same organization built a new laboratory which was heated by steam, and while the temperature could be held within reasonable limits in the darkrooms, the drying conditions, as we understand them today, were still poor. The film in this plant was transferred from the racks to drums 10 feet in diameter having slats about one foot apart. The air used for drying was taken from the outside, drawn over steam radiators, and blown directly at the film. When the air outside was very dry, the film dried too quickly, sometimes in 15 minutes. In humid or foggy weather, film was known to stay wet for 24 hours.

To our knowledge, the first engineered film laboratory was built at Fort Lee, N. J., in about 1914. More careful study was given to the design and arrangement of this equipment, and with the coöperation of air conditioning engineers, a system of controlling temperature and humidity was installed in the printing, perforating, and drying rooms. During the design of this system, considerable thought was given to the distribution of air within the drying rooms, and a new system was evolved that has since been used in practically all laboratories using the drum system.

In designing the modern film laboratory many new problems present themselves. Quantity production, maintenance of production schedules, and many other obvious factors have emphasized the importance of equipment that is simple, reliable, and automatic.

One of the most important factors is the problem of removing dust. Ever since the beginning of the photographic industry, many precautions have been taken to protect the delicate surface of the film on its journey through the laboratory. Small particles of dust adhering to its surface may cause considerable damage, and this factor, regardless of the size or type of laboratory, has always been a major consideration.

A second important factor is that of maintaining constant temperature and humidity in the various dry rooms or cabinets. The use of individual automatic temperature and humidity controls in drying rooms or cabinets permits positive drying schedules to be maintained regardless of outside atmospheric conditions. This in turn eliminates the possibility of curling and distortion of the gelatin surface, and contributes to the production of a soft, pliable, flat film.

A third important factor is the control of temperature and humidity of the various work rooms. The atmosphere in these rooms should be sufficiently humid to prevent the film from becoming too dry and brittle. A brittle film is very difficult for the printing machines to handle, and is quite likely to break. A high humidity in the printing rooms reduces the amount of static electricity being generated and thus avoids a tendency to fog the film.

A fourth factor of considerable importance is that of controlling the temperature of the developing solutions. It is generally conceded that the temperature of these solutions should be held within $\pm 0.5°F$. The reason for such extreme accuracy is that the relationship between the time of development and the temperature of the solution is a fixed one. Modern laboratory air conditioning equipment usually includes a refrigeration system which, by means of its automatic features, maintains the temperatures of the developing and fixing solutions constant and at the desired values.

With the advent of sound, a new factor has further complicated the situation. Sound track negatives, after being developed, must be synchronized perfectly with the positive film, and the close control of the humidity and temperature of the various work rooms has helped to simplify this problem. Without control, variations of relative humidity produce corresponding variations of the moisture

content of the films, resulting in changes of size and length and making synchronization exceedingly difficult, if not impossible.

Fig. 1 is a diagram which shows the values of temperature and humidity being maintained in laboratories that have complete air conditioning equipment, including refrigeration equipment which serves not only to cool and make the air less humid during the summer, but also to maintain constant the temperature of the developing and fixing solutions.

Following the course of the film through the laboratory, it progresses first through the loading room and the breakdown room, the temperatures of which are held constant and, more important,

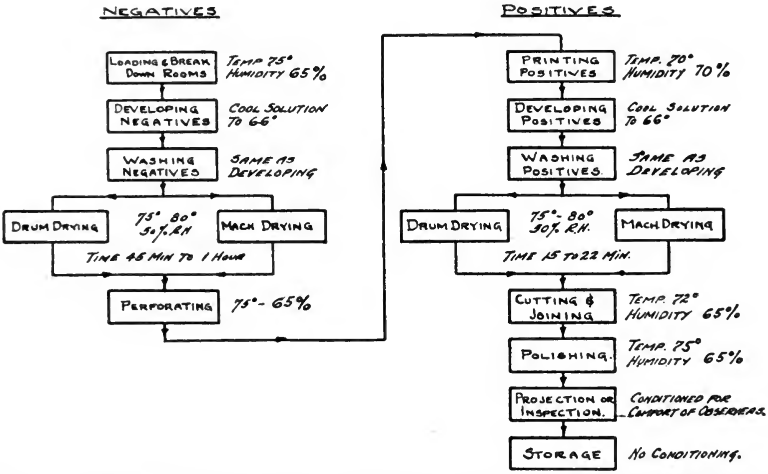

FIG. 1. Film schedule in an air conditioned laboratory showing conditions of temperature and humidity maintained.

the relative humidity of which also remains constant. The film then enters the developing room where it passes through the various developing and fixing solutions and then through the wash water into the dryer. A typical layout for the developing machine and drying cabinet is shown in Fig. 2. Each drying cabinet has its own fan and filter, designed not only to recirculate the conditioned air within the cabinet but to draw its supply of conditioned air, under individual automatic control, from a central-station air conditioning system. The arrangement of several such cabinets with their individual circulation units and the main duct is shown in Fig. 3. The recirculating units not only allow for the individual operation of

the cabinets and provide great flexibility of operation of the dry boxes, but also assist in economizing on refrigeration and steam. By means of automatic controls only enough conditioned air is supplied to the system to maintain the proper conditions for drying, the circulation being maintained mainly by recirculating the air. This method is far more economical than the ordinary method of first conditioning all the air and then heating it to the desired temperature.

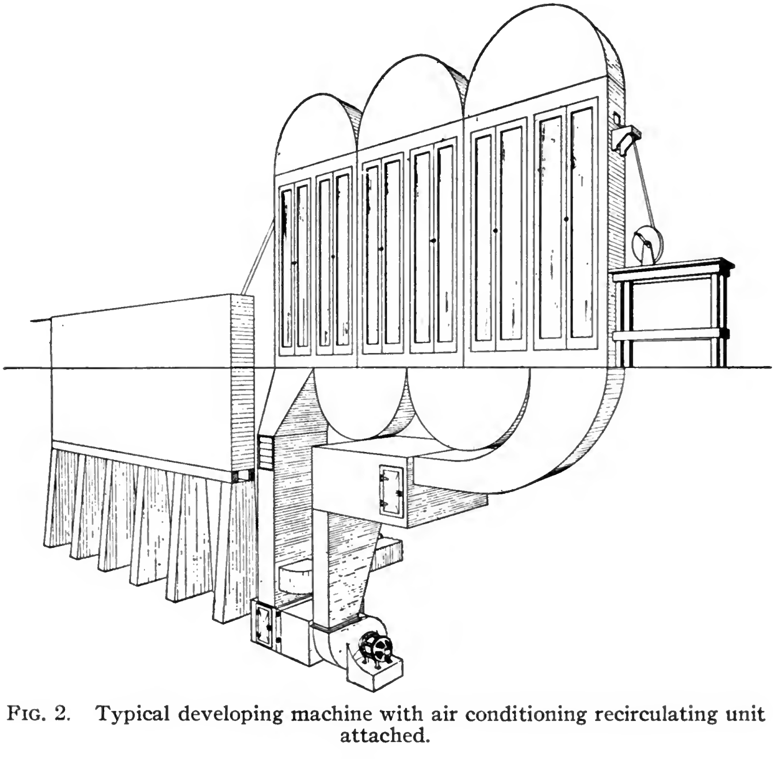

FIG. 2. Typical developing machine with air conditioning recirculating unit attached.

It will be noted that all the air entering the cabinet is thoroughly filtered, and great precautions are taken to maintain pressures within the cabinets at all times. This pressure prevents the room air from entering the cabinets and changing the conditions for drying. In this laboratory, the developing rooms themselves are supplied with clean conditioned air, and, therefore, any infiltration of air into the cabinets should not cause difficulty because of dust. However,

by maintaining pressures within the cabinets this remote possibility is removed.

The film is dried at a uniform rate in each cabinet, and progressively as it passes through the several stages. The velocity of air passing through the dryer is kept constant by the recirculation unit. The rate of drying is governed by automatically controlling the temperature and humidity of the air which circulates through the individual cabinets. It is the usual practice to maintain the temperature not much in excess of 75°F. in these dryers and the relative humidity at a value of 50 per cent or more. By raising the

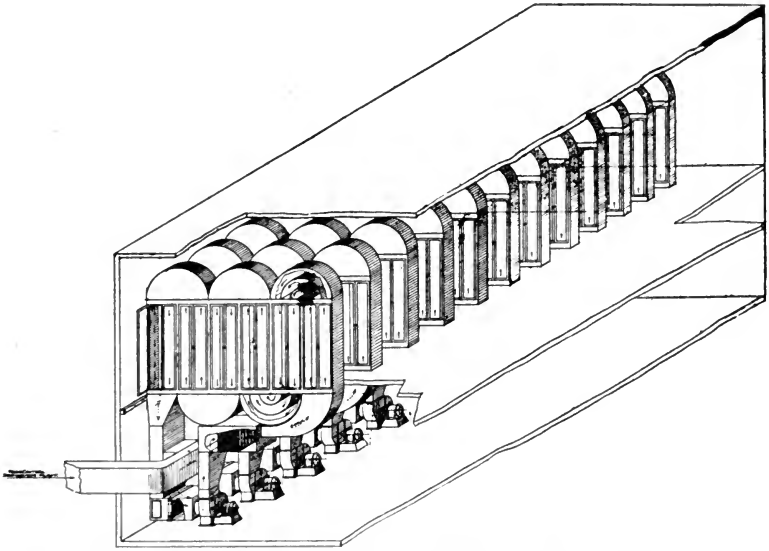

FIG. 3. Typical layout of cabinet dryers and equipment.

temperature or by lowering the humidity the drying can be accelerated; however, if the rate of drying is too great, the quality of the film is impaired, and in extreme cases the film may come out curled and brittle and be unfit for use. In general, the best time for drying negatives as they are fed from the developing and washing machines is from 45 minutes to one hour. Positives are sent through the dryers in from 15 to 22 minutes. Where speed is a desirable item, as, for instance, in the rapid production of a newsreel print, drying within cabinets of this type is frequently accomplished in about $7^1/_2$ minutes. This is somewhat detrimental to the quality of the film.

It is quite important to be able to regulate the individual cabinets separately because not only is the developing time being continuously changed in each cabinet due to the changes which occur in the film during development, but the drying time changes as well. Experience also has shown that certain types of film are more difficult to dry than other types.

Advancing from the dryers to the negative assembly room the film is handled again in an atmosphere which is kept clean, and the temperature and humidity of which are controlled by the air conditioning system. The object of conditioning the air in this room is to preserve the pliability and general quality of the film, to prevent the evaporation of alcohol or other volatile substances from the base, to maintain a state of comfort for the workers, and to reduce the possibility of marking the film by perspiring fingers.

In the printing rooms particular attention is given to the humidity, which is held sufficiently high to prevent the generation, or at least the discharge, of static electricity in the printing machines. These discharges, under uncontrolled conditions, very often seriously fog the positive.

Another object of controlling the condition of the air in the printing room has already been cited, namely, that of preventing a change in the size and length of the film, which would make it difficult to synchronize the sound track negative and the positive print.

The control of developing, fixing, and washing baths, and the subsequent drying of positive films is, in most essentials, the same as that described in connection with the negatives, with the exception of the fact that the drying is accomplished in a much shorter time and in drying cabinets which have five compartments and loops, compared with six compartments with six loops for the negative.

Again, after the drying operation the film passes into the hands of workers in the cutting and joining room, where the condition of the air is again controlled to retain the pliability of the film and maintain clean working conditions.

In air conditioned laboratories the control is usually extended to the polishing and treating room for similar reasons, and also for preventing the occurrence of static discharges.

Finally, it is desirable, since air conditioning equipment is available, to maintain comfortable conditions in the projection room and in the booth. The heat should be exhausted independently of the projection lantern and a small supply of conditioned air

should be delivered directly to the booth. A branch supply from the system which conditions the air in the printing or cutting rooms is usually sufficient for the projection room and the booth.

TEMPERATURE CONTROL OF SOLUTIONS

The accurate technical control of the temperature of developing and fixing solutions can be suitably described as liquid conditioning, a process which is closely allied with that of conditioning air.

Previously in this paper we have touched briefly on the fact that the refrigeration equipment used for cooling water, in addition to assisting in conditioning air, is also used to supply cold water for maintaining an accurate control of the temperature of the developing and fixing solutions.

In the modern laboratory each developing machine has its own developing solution tank and an independent circulating system. The solution is pumped from this tank to the tank in the developing room and then back to the collecting tank. The collecting tank is equipped with coils communicating through automatically controlled three-way valves to cold and warm water circulating systems. The warm water circulating system includes a steam-heated interchanger, while the cold water circulating system passes through an interchanger to which cold water is supplied from the refrigeration system.

Individual automatic thermostats for each developing solution tank maintain the accurate control necessary. Needless to say, this rather complicated piping system must be designed most carefully. Whatever the degree of accuracy of the thermostat, unless the heat interchanger and the circulating systems are properly designed, it will be impossible to maintain the accuracy of temperature control desirable.

In this regard, it is also important that the refrigeration system operate with great flexibility, producing immediate and continuous cooling of the moving liquid through small ranges of temperature.

The type of refrigeration in use in such laboratories as described later in this paper is most admirably suited from this point of view.

AIR CONDITIONING EQUIPMENT USED IN FILM LABORATORIES

A complete air conditioning system, whether it is used for the drying and processing of film to regulate the conditions governing the efficiency of production and the quality of the product, or simply to

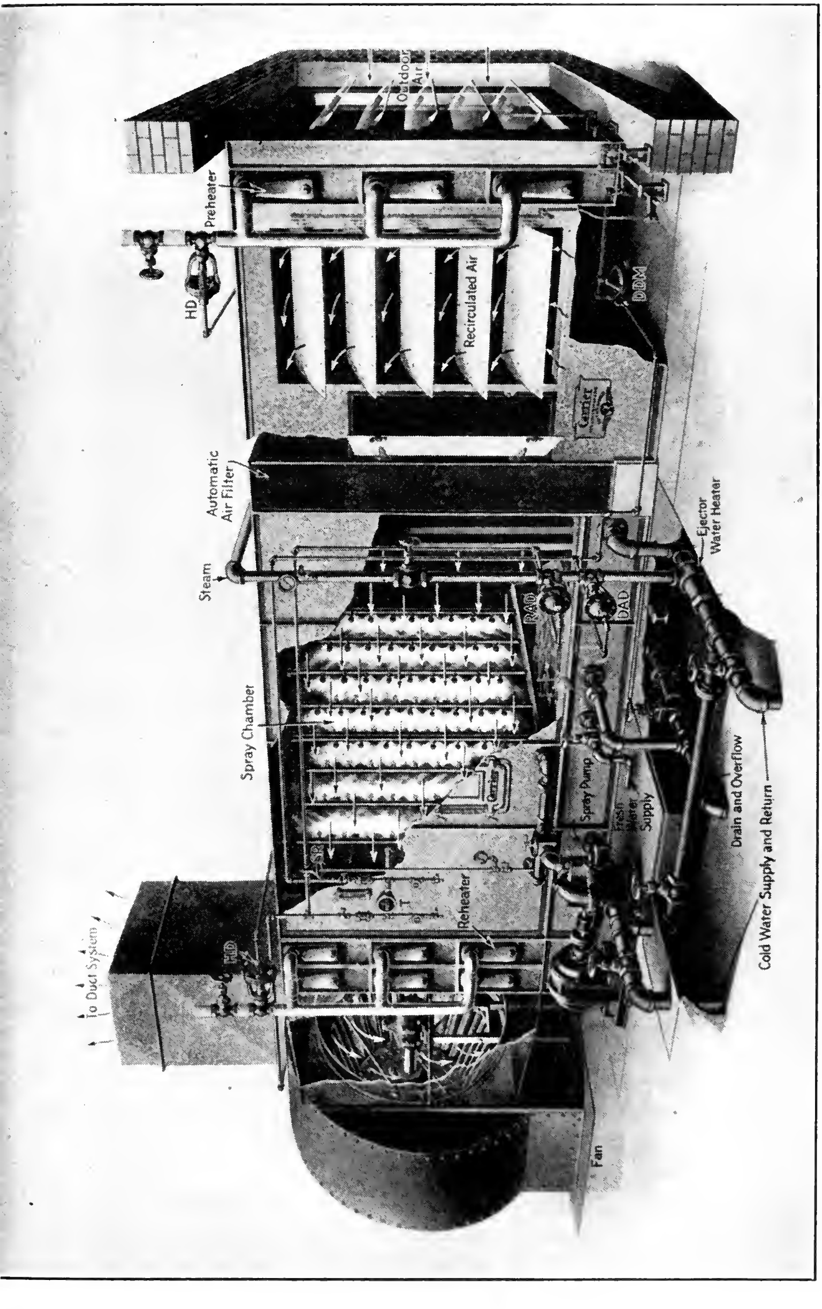

FIG. 4. A typical central station air conditioning unit, showing the spray chamber, the automatically controlled air dampers, the heaters, the auxiliary air filters, and the centrifugal fan which delivers the conditioned air to the duct system.

produce comfortable conditions for people within doors, must be considered as a coördinated unit, and not in terms of separate pieces of equipment, such as fans, air washers, and refrigeration machines. However adequate the capacity and however efficient the operation of any particular unit in the system, if the system is not carefully designed, assembled, and coördinated as a whole, it will fail in its

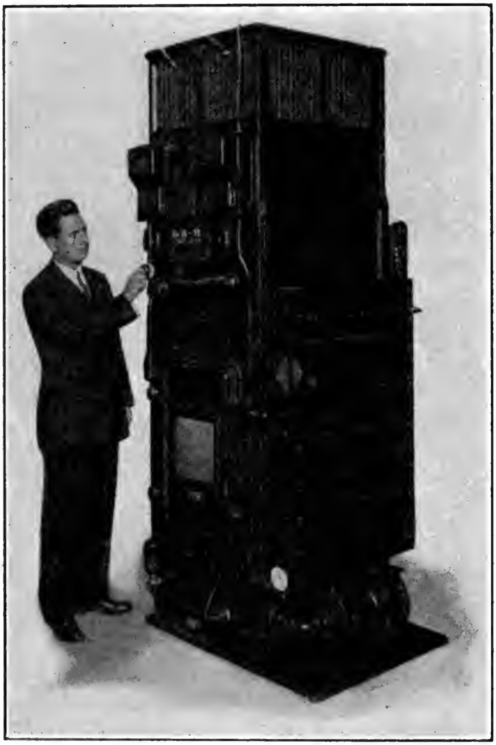

FIG. 5. Standard unit air conditioner.

purpose. Thus, the designs and assemblies of complete systems with reference to the particular application and the results which are ultimately to be accomplished are the problems to which air conditioning engineers devote themselves.

It is worth while here, however, to describe briefly some of the major pieces of equipment which enter into a complete air conditioning system.

THE AIR CONDITIONING UNIT

The central air conditioning unit consists essentially of a spray chamber wherein the air is washed and its humidity is fixed according to the controlled temperature of the spray water, a fan which draws the air through the spray chamber and delivers it to the metal duct system and the auxiliary equipment of water piping, automatically controlled dampers, heaters, *etc.*

Fig. 4 shows in considerable detail, an air conditioning unit of the type employed in film laboratories. The unit is connected to a source of cold water usually supplied through a refrigerating machine and to a source of steam usually from the plant's own boiler. During

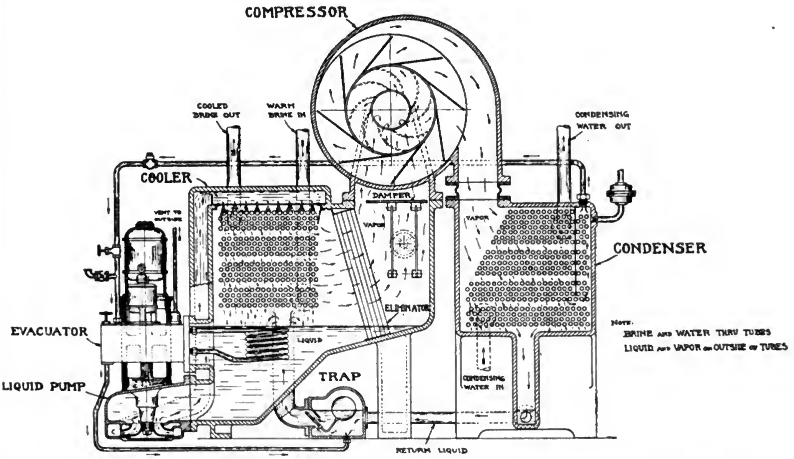

FIG. 6. Diagrammatic arrangement of centrifugal refrigeration unit.

the seasons when the humidity of the outside air is excessive, condensation occurs when the air comes in contact with the refrigerated spray water. A definite dew-point or condensation temperature of the air is established by automatically controlling the cold water supply.

For example, it is not unusual during summer weather for the outdoor air to have a dew-point or condensation temperature of 65°, while in the printing department, it is desirable to maintain a temperature of 70° F. with a relative humidity of 65 per cent. This calls for a dew-point temperature of approximately 57°. So, the automatic controls are set to deliver the air from the spray chamber at 57° after which it is heated, either by passing it over heaters or by

mixing it with warmer air, and its temperature is raised to 70°. In reducing the dew-point from 65° to 57° we have condensed approximately two grains of moisture from each cubic foot of air passing through the spray chamber.

During the winter, the spray chamber serves as a humidifier. With outdoor dew-point temperatures of 35° or below, it is necessary to raise the dew-point to 57° adding in this process several grains of moisture to each cubic foot of air.

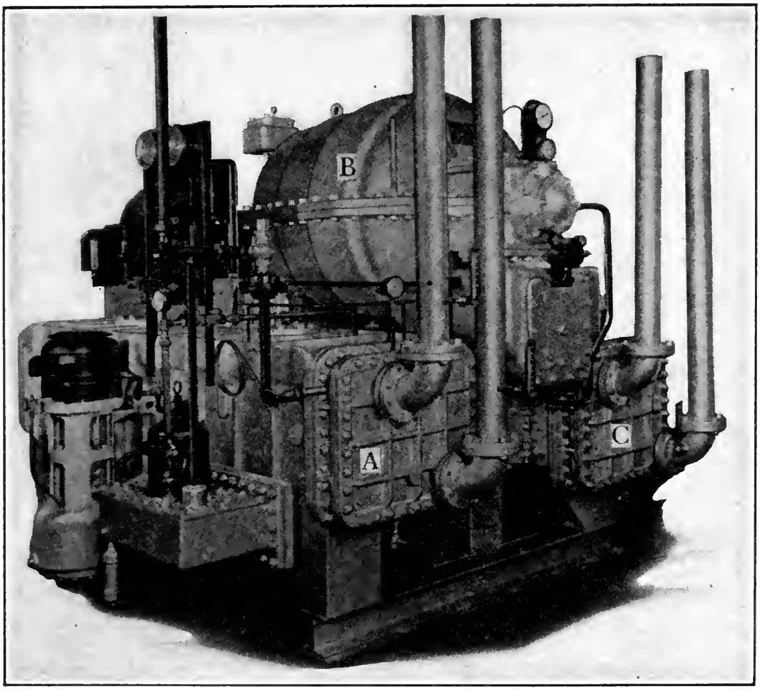

FIG. 7. A complete centrifugal refrigeration unit: (*A*) the evaporator or cooler; (*B*) the centrifugal compressor; (*C*) the condenser.

In the large laboratory equipment which we have described, a central station air conditioning unit of the above type supplies conditioned air to the individual recirculating units on the drying cabinets, while one or more like units supply the conditioned air to the various printing and cutting departments.

Fig. 5 is a standardized unit air conditioner, which serves in all details the same purposes as the large central station air conditioning

system but is designed for small laboratories and individual departments, one or more of the units being placed directly in the room to be conditioned. The development of these units has very considerably extended the use of air conditioning systems, making it possible for even small photographic laboratories, as well as many other kinds of plants, to have control over indoor weather conditions without undue expense.

REFRIGERATION

Cold water for the air conditioning system can, of course, be obtained from almost any of the several types of refrigerating systems. In some instances, it is even found that sufficiently cold well water is suitable for controlling humidity and temperature in cer-

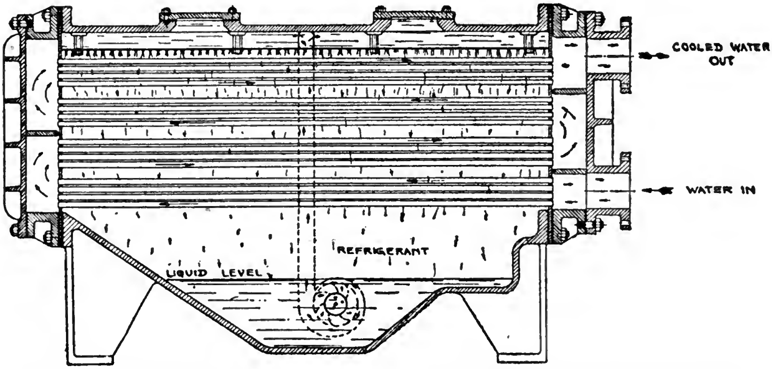

FIG. 8. Construction of water cooler in centrifugal refrigerating system.

tain processes. It is very rare, however, that a sufficiently cold supply is available for film laboratory work since water of about 40°F. to 45°F. is necessary in order to produce the desired dew-points.

The centrifugal refrigeration system developed especially to meet the requirements for conditioning air is now very widely used in film laboratories, theaters, and sound stages.

Fig. 6 shows diagrammatically the assembly and operating cycle of the complete system. The compressor is mounted directly on top of the cooler and condenser, which are of standard shell and tube construction. These are the three essential elements and have the same functions in any compression refrigerating system, but vary greatly in form and construction. The motor for driving the compressor is connected through gears to the compressor shaft

and is mounted on one end of the cooler and condenser. The auxiliaries are a small refrigerant pump and a purge pump. The refrigerant pump elevates the refrigerant from the bottom of the cooler to the top and showers it over the tube surface. This gives a flash type of evaporation, which is very efficient. Since this system operates at pressures below atmospheric on both the cooling and condensing side, a small automatic purge unit for maintaining the system free of air or non-condensable gases is provided.

All these elements are assembled in one compact unit, shown in

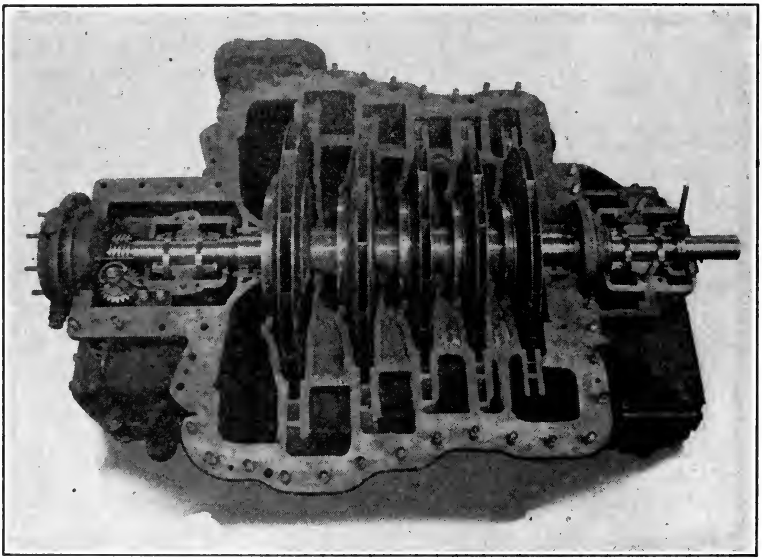

FIG. 9. Interior view of centrifugal compressor.

Fig. 7. One of the unique features of this system is the absence of valves. There is no valve in the compressor itself; neither is there an expansion valve nor a valve of any other type in the entire circuit.

In the centrifugal system, the spray water is pumped directly through the shell and tube type cooler (Fig. 8), so that the efficiency of heat transfer from the water to the refrigerating medium is high.

The construction of the compressor is similar to that of a multistage centrifugal pump. Fig. 9 shows the compressor with the top cover removed. The rotor is supported on two standard sleeve bearings which are ring-oiled. There are no other points of contact

between moving and stationary parts, which illustrates the simplicity of construction and the absence of sources of mechanical trouble.

The refrigerant employed in centrifugal systems is unique in the safety and ease with which it may be handled. It is dichloromethane (CH_2Cl_2) known by the trade name, Carrene. It is not combustible, and being a liquid at normal atmospheric temperatures and pressures, Carrene may be carried in open containers, like water. To charge the refrigerating machine with Carrene, the liquid refrigerant is simply drawn by vacuum into the system from an open container. Since the normal atmospheric boiling point is 105°F., at a pressure of 29.92 inches of mercury, it is apparent that all parts of the system are at pressures below that of the surrounding atmosphere.

THE AIR FILTER

There are three general types of air filters used in film laboratory work. The first is the sectional type, viscous-coated air filter cell, consisting of a shallow metal case packed with filtering "media" of split wire having expanded metal covers front and back for holding the filtering "media" securely in place, but allowing free passage to the air. This type of filter is shown in Fig. 10. The filter "media" has large voids in the front section where the larger solids are removed, the voids becoming smaller and the "media" more densely packed toward the side of exit of the air. The unit is manufactured in one size, but any number of units may be combined to filter large quantities of air.

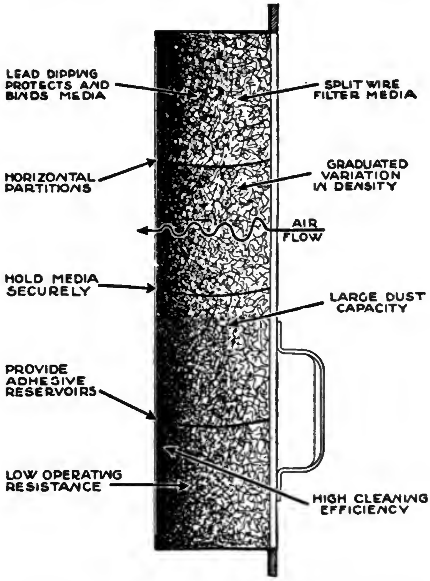

FIG. 10. The viscous coated air filter, sectional type. A filtration surface is produced by dipping the unit in a viscous fluid. Periodic removal of the sections is required for cleaning and recoating.

The second type is the automatic viscous-coated air filter shown in Fig. 11. In this filter the filtering "media" consists of a number

of closely overlapping screen panels which form a continuous movable curtain. When the filter curtain enters the oil bath in the reservoir at the base of the filter, the panels are automatically separated and hang vertically. This type is quite as effective as the sectional filter, but has the added advantage of being completely automatic. Its efficiency remains practically constant with very little attention.

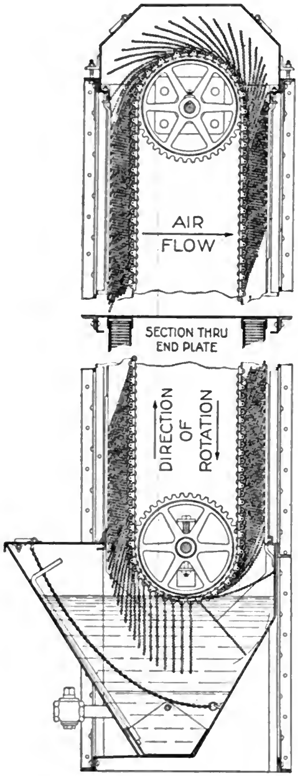

FIG. 11. The viscous coated air filter, continuous self-cleaning type.

The third type of filter is known as the air mat pocket type, and differs from the two previously mentioned in that the filtering "media" is a material of fibrous texture. This filter is the dry type and is used in certain types of installations where oil may prove objectionable. This type of filter is shown in Fig. 12.

Regardless of which type of filter is used, the method of making the proper connections to the filters and conditioned spaces is extremely important. Regardless of how efficient the filter may be in removing dust and dirt, if any infiltration takes place between the discharge connection of the filters and the conditioned space itself, most of the good obtained by the filters is lost. Considerable care must be given to this point in the design of the equipment, and positive pressures must be maintained in order to eliminate infiltration or air leakage.

Summarizing the necessary attributes of air conditioning equipment for the film laboratory we arrive at the following:

(1) All outside air must be filtered before it enters the laboratory.

(2) Pressures must be maintained in all parts of the laboratory at all times to prevent infiltration of outdoor dust.

(3) Individual dry rooms or cabinets should be individually conditioned and automatic control equipment should be provided for flexible operation.

(4) Each developing solution system should have its individual thermostatic control equipment.

(5) Air conditioning units should be simple, reliable, and accessible.

(6) The refrigerating machine should be simple, safe, compact, and easily accessible.

(7) Individual work rooms, such as the printing room, assembling room, breakdown room, *etc.*, should have individual automatic thermostatic and hygrostatic control equipment.

(8) Humidities should be maintained sufficiently high in the various rooms to prevent the generation of static electricity.

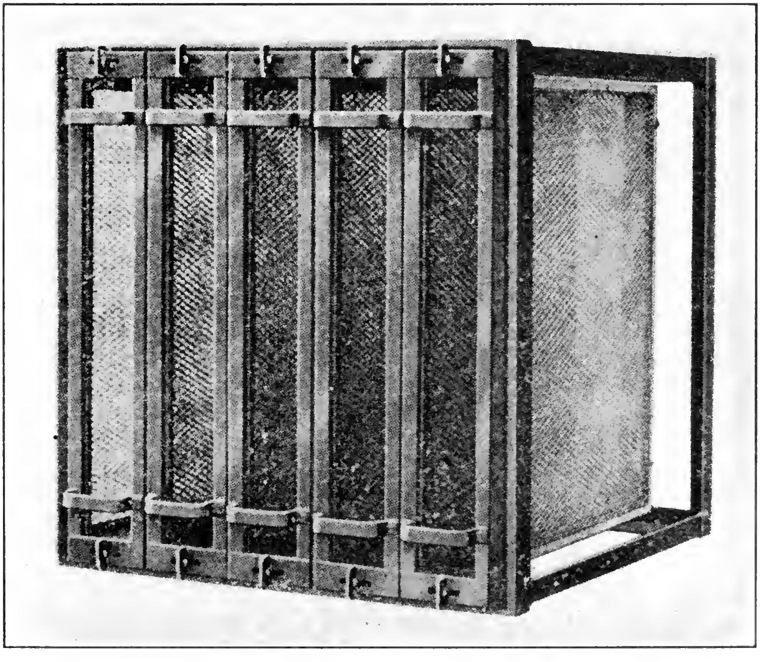

FIG. 12. The dry air mat pocket-type air filter.

(9) Humidities and temperatures should be maintained constant at all times to make possible the manufacture of a strong, pliable film.

(10) Recirculating systems should be used wherever possible for better control of conditions as well as for effecting a saving in operating costs, both in refrigerating and heating.

(11) Heating equipment should be compact, safe, and adaptable to automatic control.

There are many other factors to be considered in the design of a complete film laboratory. However, the authors have attempted

to touch upon only the general features and possibilities of complete air conditioning equipment for the modern film laboratory. Each laboratory, no doubt, has its specific problems which introduce many variations in detail.

REFERENCE

[1] LINDSAY, D. C.: "Air Conditioning as Applied in Theatres and Film Laboratories," *Trans. Soc. Mot. Pict. Eng.*, **XI** (1927), No. 30, pp. 335–65.

DISCUSSION

PRESIDENT CRABTREE: What advantage has an oil filter over the air mat type of filter?

MR. SIMONDS: Generally we prefer the air mat type as no oil is used in the system. The air mat is built in such a way that when it becomes dirty it can be taken out and new sheets put in. This is a very easy job and the sheets are quite cheap.

PRESIDENT CRABTREE: What is the drop in air pressure from one side to the other as the filter becomes older?

MR. SIMONDS: That depends on the velocity. When the filters are clean the pressure under normal conditions is about $^1/_4$ inch of water. As the filter becomes dirty the pressure builds up to perhaps $^3/_8$ or $^1/_2$ inch of water. That is an easy way of telling when the filter is dirty. So long as the pressure remains at the initial value of $^1/_4$ inch the filter is clean.

PRESIDENT CRABTREE: Have you had any experience with cloth filters?

MR. SIMONDS: We have used the bag filter known as the Holly Type, which is very efficient, although quite cumbersome.

PRESIDENT CRABTREE: How do you clean these filters?

MR. SIMONDS: Remove the bags and wash them.

PRESIDENT CRABTREE: Do any fibers get in the air from the air mat filter?

MR. SIMONDS: The experience we have had doesn't seem to show that, and we have had no trouble along these lines.

PRESIDENT CRABTREE: Do you find that a humidity of 55 per cent is satisfactory in the printing room?

MR. SIMONDS: The humidity in the various work rooms on the jobs on the West Coast is kept between 65 and 70 per cent.

PRESIDENT CRABTREE: The film is packed in the manufacturing plant at a humidity of about 70 to 75 per cent.

MR. SIMONDS: Fifty-five per cent is quite low for the printing room, and a higher humidity of approximately 70 per cent is generally preferred.

A NEW 35-MM. PORTABLE PROJECTOR*

HERBERT GRIFFIN**

Summary.—*A new 35-mm. portable projector is described. The optical system consists of either the T-20, 900-watt or T-20, 1000-watt lamp, Bausch and Lomb Cinephor condensers, and the lens mounts are so constructed as to take full-size professional no. 2 or series II lenses. The projector is of the straight-through threading type. All the operating parts are directly connected to the motor, no belts being used. Framing is accomplished by the rotating-sprocket method.*

A new type of sound gate without tension shoes forms part of the equipment. The revolving shutter is placed between the projection lamp and the aperture, and functions also as an automatic fire shutter. The equipment is entirely enclosed within its own case and weighs approximately 100 lbs.

The portable projector described in this paper is of fundamentally new design, and has been found to produce results comparable with those obtained with the best theater equipment. It is the first apparatus of its kind, designed particularly for picture projection and sound reproduction and in no sense is it to be confused with that type of equipment consisting of makeshift apparatus assembled from silent equipment with sound attachments added.

Excellent picture projection and first-class sound reproduction, of course, are major considerations in designing new equipment, and the optical system for picture projection has been selected with this in mind. The illuminant may be either the T-20, 900-watt, 30-ampere monoplane filament lamp, which has been generally used with excellent results in medium sized and smaller motion picture theaters, or the T-20, 1000-watt, 110-volt lamp. A pre-focus mogul base lamp socket is provided so that these lamps may be used interchangeably and, inasmuch as a separate circuit is provided for this pre-focus socket, no internal wiring changes are necessary regardless of the type of lamp selected. It is only necessary to plug the 110-volt, a-c. line into the lamp receptacle indicated or, when using the 900-watt lamp, a transformer designed for use in connection with it may be readily connected in the circuit.

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** International Projector Corporation, New York, N. Y.

The condensing system is the Bausch and Lomb Cinephor PM-15 and PM-25, and the projection lens mounts are so constructed that any type of lens may be used having dimensions standardized by the Society. This means that the full-size no. 2 or series II lenses may be readily accommodated in any focal length.

The sound reproducing equipment has received equal consideration: the exciter lamp socket is rugged and, therefore, entirely free

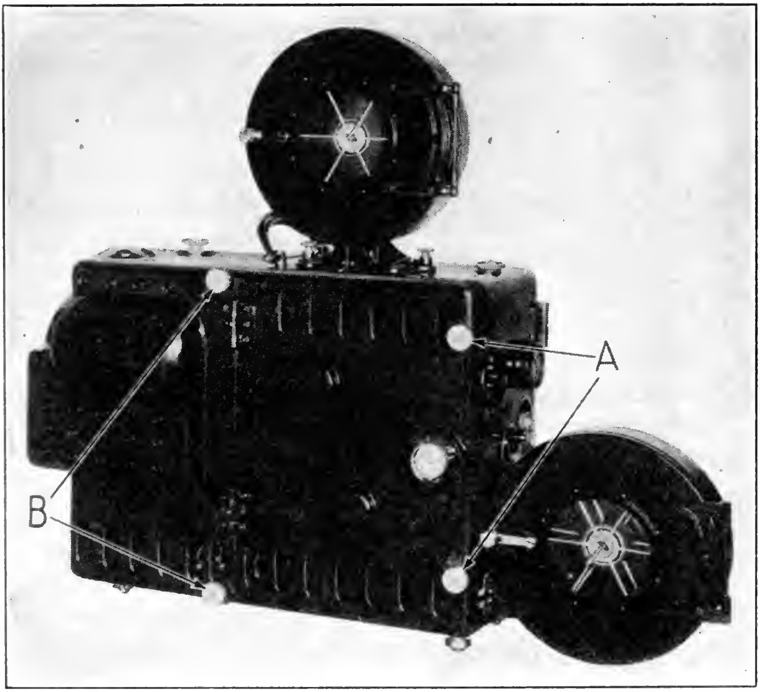

FIG. 1. External appearance of the projector from the operating side.

from vibration, and the optical system is sturdy and rigidly mounted. The sound reproducing gate deserves special attention inasmuch as no tension shoes or springs are used at the sound take-off aperture. The film, after leaving the sound gate feed sprocket, is passed over a roller and tension is applied at this point. A curved plate is provided, the curvature following the tangent of the roller, and the film, after passing the sound aperture plate, follows the tangent of the plate over the rim of the sound sprocket. It is apparent, therefore,

that the film remains in absolute contact with the sound aperture plate and that not only is buckling eliminated at this point, but, because there are no tension shoes or springs in contact with the film, there is no danger of emulsion collecting and causing the many defects in sound reproduction traceable to this source. The film is laterally guided by the edge on which the sound track appears so that there is no weaving of the film in passing the reproducing light beam.

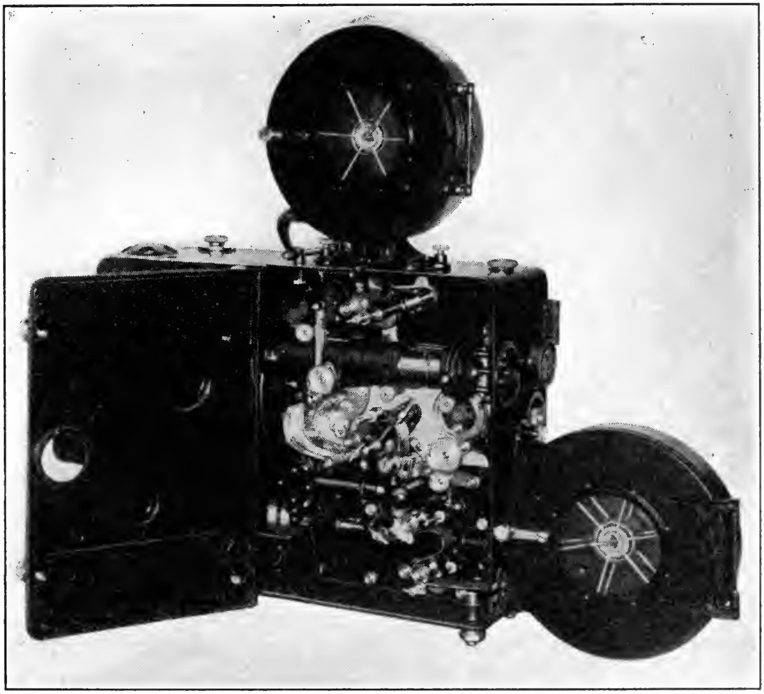

FIG. 2. The projector with door opened showing the film operating mechanism.

The photoelectric cell is mounted directly behind the sound aperture plate, and because there are no lenses of any kind between the plate and the photoelectric cell the maximum amount of light is passed through to it. A shield completely envelopes the PE cell except for a small window to allow the passage of light from the optical system, and should it become necessary to quickly replace the PE cell, this shield may be immediately removed and the cell instantly replaced.

Fig. 1 shows the external appearance of the projector. This shows the operating side of the projector with the doors closed. By opening the two latches, *A*, and opening the door, the entire film operating mechanism is exposed for threading, as shown in Fig. 2. It should be noted that the equipment is of the straight-through threading type, the feed magazine being above and the take-up magazine below. By opening the two latches, *B* (Fig. 1), the rear section of the door is opened, as shown in Fig. 3 (Slide 3), thus exposing the projection lamp, condensing system, shutter guard, motor, *etc.* This rear door,

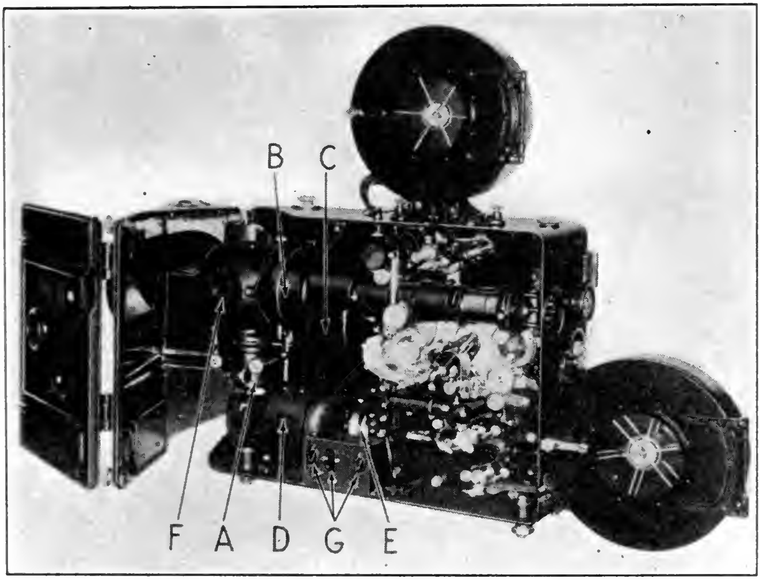

FIG. 3. Projector with rear door opened showing projection lamp, condensing system, motor, *etc.*

however, is normally kept closed at all times, as it is necessary to open only the forward door to place the film in the equipment.

Referring to Fig. 3, the pre-focus socket providing interchangeability of lamps is seen at *A*, the Cinephor condensing lens system at *B*, the rear shutter housing on the operating side at *C*, and the operating motor with its cooling fan at *D*; the mechanical filter between the motor and driving mechanism may be seen at *E*; an auxiliary shield is seen at *F*, the purpose of this shield being to protect the projectionist's eyes from the bright glare of the projection lamp should

it at any time be necessary to open the rear door while the projector is in operation. At *G* will be seen three switches, one for the exciter lamp, one for the projection lamp, and the third one for the operating motor; these are readily accessible through the rear door, as shown in Fig. 1.

A complete idea of the arrangement of the film operating parts may be obtained by referring to Fig. 4, which also shows the film in place

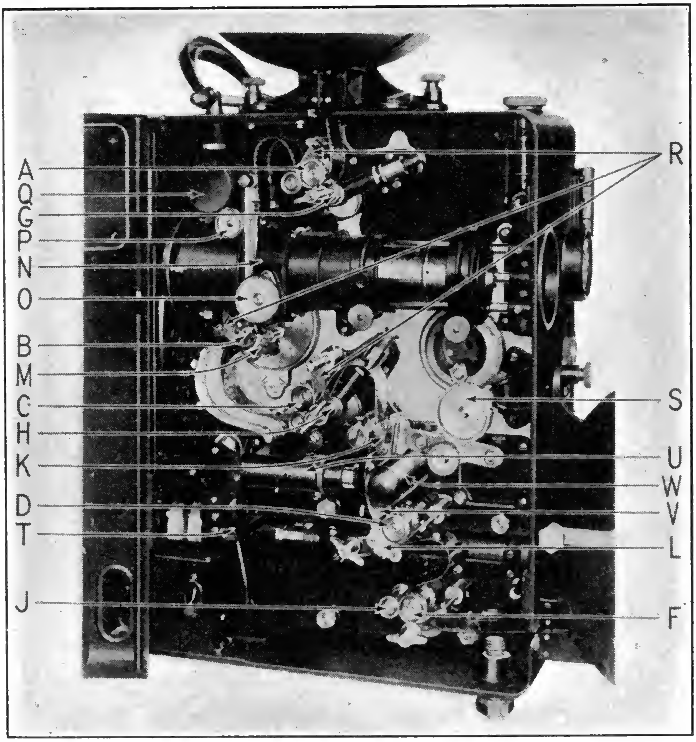

FIG. 4. Showing arrangement of film operating parts.

for operation. At *A* is the feed sprocket, at *B* the intermittent sprocket, at *C* the sound gate feed sprocket, at *D* the constant-speed sound sprocket, at *F* the take-up or hold-back sprocket, at *G*, *H*, and *J* are the pad rollers which maintain the film on the two feed sprockets and the hold-back sprocket, at *K* and *L* are the tension shoes for the sound tension roller and the constant speed sprocket, respectively; and at *M* the tension shoe for maintaining the film on the inter-

mittent sprocket. All these pad rollers and tension shoes are so designed that they are locked in either the open or closed position, and the possibility of their changing positions with relation to the sprockets when closed is entirely eliminated by the positive stops provided which, once adjusted, always remain fixed in the same position. At *N* is the motion picture projection gate which may be opened or closed by turning knob *O* to the right or left, respectively, and in

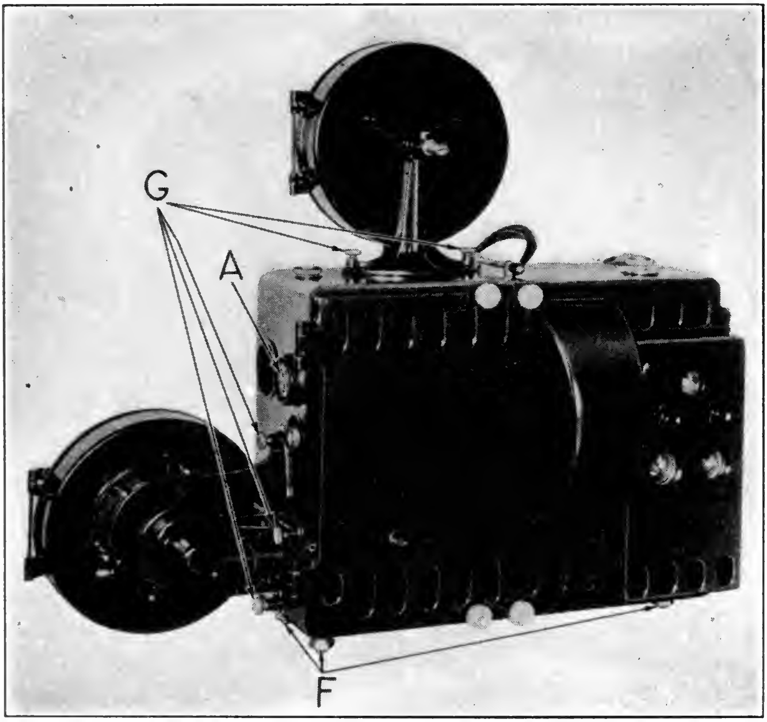

FIG. 5. View of rear of projector.

either position the gate is securely locked. A double aperture of the vertical sliding type is provided, and by turning knob *P* either the silent film projection aperture or the sound film projection aperture is brought into place and locked in position. At *Q* is a pilot light to give illumination for properly placing the picture in the frame when threading. Stripper plates are provided for all the sprockets, three of which may be seen at *R* (Fig. 4). At *S* is seen the framing

handle controlling the rotation of the intermittent sprocket for framing the projected picture either before or during operation; at *T*, *U*, *V*, and *W* are seen the exciter lamp socket, optical system, sound aperture plate, and photoelectric cell shield, respectively. The path of the film through the mechanism may be readily followed by a careful study of this picture. The entire projector is built up of separate assemblies, any one of which may be readily removed at will without unduly disturbing the other parts.

In Fig. 5 may be seen the rear or non-operating side of the pro-

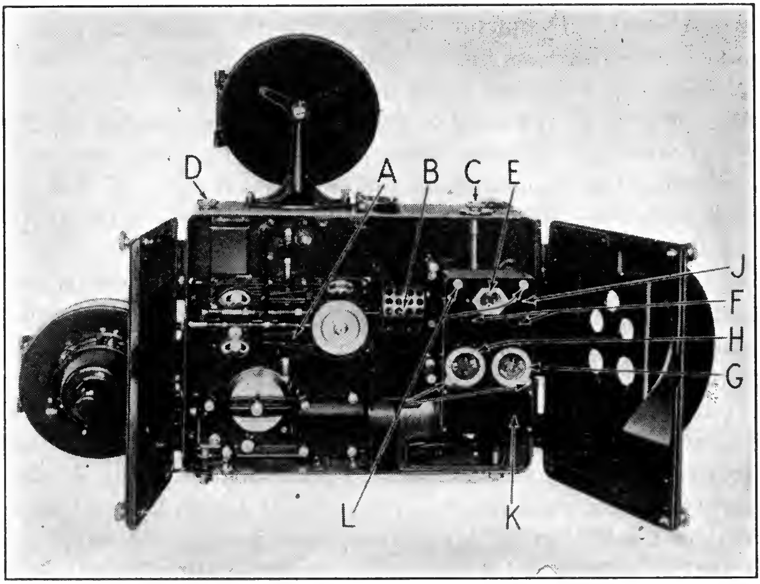

FIG. 6. Showing rear door of projector opened, exposing the mechanical operating parts.

jector. At *A* may be seen the receptacle by means of which polarizing current is carried to the photoelectric cell. The operating mechanism, it will be noted, is entirely enclosed on this side, also by means of two doors. Opening these doors exposes to view the mechanical operating parts of the equipment, as shown in Fig. 6. By referring to this illustration it will be noted that the equipment is throughout directly connected to the motor; no belts of any kind are used, and a mechanical filter is placed between the motor and the mechanism so that vibrations or other impulses from the motor cannot be trans-

mitted to the mechanism proper. The driving shaft continues straight through the lower part of the projector and is gear-connected to the constant-speed sprocket shaft, the vertical driving shaft driving the remainder of the projector and the take-up magazine. The constant-speed sprocket is satisfactorily filtered by the same type of filter employed in the motor shaft, and there is but one pair of gears between the driving shaft and the constant-speed sprocket shaft.

The intermittent movement and shutter synchronizing means are mounted in one common casting, *A* (Fig. 6). This system allows for but one pair of gears between the shutter shaft and the intermittent movement. The picture is framed by rotating the intermittent sprocket, which is accomplished by turning the framing handle shown at *S* (Fig. 4), when the entire intermittent and shutter support casting, *A* (Fig. 6), is rocked in the arc of a circle, maintaining absolute synchronism between shutter and intermittent movement, and allowing the elimination of the entire train of gears ordinarily present for accomplishing this result in all other types of motion picture projectors.

Oiling of the mechanism is accomplished through oil tubes running directly to every bearing from common manifolds, and the type of bearing used, together with the excellently designed lubricating system, provide absolute assurance against binding of the mechanism at any time.

The revolving cut-off shutter is placed between the condensing system and the aperture, as in modern professional equipment, and is entirely enclosed, as shown at *B*, Fig. 6. It is well known that the placing of the shutter in this position immediately reduces the heat incident upon the film by fifty per cent, and inasmuch as the light beam is always of the same dimension in this position it is unnecessary to use shutter blades of varying widths. This shutter performs a double function: no fire shutter, according to the generally accepted term, forms part of this equipment but the revolving shutter when the projector is idle is entirely closed throughout its 360 degrees. When the projector reaches a predetermined speed two blades of the revolving shutter fly open behind two fixed blades, the shutter then becoming in effect the usual cut-off shutter with two 90-degree blades. Attached to the shutter shaft also is a fan for forcing a cool draft of air over the entire rear section of the equipment containing the lamp house. At *C* is shown a douser knob by means of which, if desired at any time, the light may be cut off from the screen while

the projector is running, and at D is shown the knob for sharply focusing the projection lens.

In the rear we see the input and output receptacles for carrying the current to and from the equipment during operation. At E is the 110-volt input from the line; this feeds the motor through the motor switch, and is wired in parallel with the two plugs, F. One of these plugs is used to feed the amplifier with 110-volt alternating current, and the other for an extension lamp or any other device requiring such a supply. At G is shown the exciter lamp feed receptacle, and at H the receptacle previously mentioned, into which is plugged the a-c. line for feeding the projection lamp. All these receptacles and the wiring connecting them are mounted in a complete assembly, J, and all connections from the lamps and motor are made on a common panel board beneath the bakelite cover, K. Any current-carrying part may be removed by disconnecting the wiring at its particular terminal on the panel board, and the entire panel board may be removed by disconnecting all the wires from the various current-carrying parts which are connected thereto, and removing the four nuts, L.

The projector may be tilted to any desired angle by adjusting the tilting nuts, F (Fig. 5). The upper and lower magazines may be easily removed by loosening screws G. The entire equipment, with magazines removed, may be packed in a trunk properly built to receive it. The entire assembly weighs approximately one hundred pounds.

PIONEER EXPERIMENTS OF EUGENE LAUSTE IN RECORDING SOUND*

MERRITT CRAWFORD**

Summary.—*Among the pioneers who were engaged in developing the motion picture art, the name of Eugene Augustin Lauste prominently appears. In the January, 1931, issue of the* JOURNAL *a brief outline of Mr. Lauste's career was presented by the Historical Committee of the Society. This paper deals more intimately with the various stages of Mr. Lauste's career, particularly with regard to his long-continued experimentation with various methods of recording and reproducing sound on film. A replica of one of Mr. Lauste's original sound picture recording and reproducing machines was exhibited at the Spring, 1931, Meeting of the Society at Hollywood.*

Too often the contrivances and machines built by early workers in an art, after a brief though strenuous existence, find their way to the junk heap long before their value as historical documents becomes apparent. Once in a while fragments survive, and occasionally whole machines find a safe resting place and later come to life, although somewhat battered by the vicissitudes through which it passed.

Some time ago when investigating the history of the development of the sound picture art, investigators of the Bell Telephone Laboratories were impressed with early work along this line as disclosed in patents and other publications of a Frenchman, Eugene A. Lauste. It was learned that Mr. Lauste was in this country and had preserved a number of parts of his original apparatus. It was considered desirable by the Bell Laboratories to preserve the Lauste apparatus and to have replicas made of it, both because of its general historical interest and because, in connection with pending patent litigation, it was desirable to present Lauste's work in concrete physical form to the Court. Accordingly, Mr. Lauste was employed to collect his apparatus and to reproduce a complete sound picture recording and reproducing ma-

* Presented at the Spring, 1931, Meeting at Hollywood, Calif. A contribution of the Historical Committee. Additional details of the career of E. A. Lauste were given by the author in a previous paper published in *J. Soc. Mot. Pict. Eng.*, **XVI** (Jan., 1931), No. 1, p. 105.

** New York, N. Y.

chine. Two of these machines were built in the shops of the Laboratories under Mr. Lauste's direction, and one of them is on exhibition at this meeting of the Society of Motion Picture Engineers. This piece of apparatus has served its purpose as an exhibit, and it is planned eventually to place it in a suitable museum where it may be inspected by those who are interested in the historical records of the sound picture art. An outline of Mr. Lauste's early experiments forming a historical setting for the apparatus on exhibition follows.

Efforts to record sound photographically are usually dated from

FIG. 1. Eugene Augustin Lauste. Born in Paris, France, Jan. 17, 1857.

Cermak's experiments in 1862, when the Viennese scientist photographed the vocal cords in action, although he made no attempt to record the actual sound vibrations.

Prof. Alexander Blake, of Brown University, in 1878 photographed the vibrations of a microphone diaphragm by means of a small mirror which reflected a beam of light on a sensitized plate kept in motion by a clock-work mechanism.

Several years later, Prof. Hermann at the International Congress of Physiology at Liege, Belgium, used a microphone in connection with a

phonograph, the sound vibrations being recorded on a strip of sensitized paper. The microphone used by Hermann was furnished with a tiny mirror which vibrated or oscillated in accordance with the sound produced by the phonograph record, the beam of light varying accordingly.

For more than a decade thereafter, numerous other experimenters, using various methods and various materials—glass, paper celluloid, *etc.*—with suitable sensitized surfaces, sought to record sound vibrations photographically. None of them, however, was able to reproduce the graphic curves of sound which their devices had photographically recorded.

Among the experimenters of this period whose names may be mentioned are Dr. Marage, the famous Sorbonne otologist, who photographed the elementary sounds of the human voice as early as 1898, using an acetylene flame; and an American, Edmond Kuhn, a pioneer inventor and constructor of camera and projection apparatus, who, in 1900 experimented with a mirror diaphragm, a lens, and an incandescent lamp, using motion picture film. Kuhn used an ordinary telephone receiver and a phonograph.

R. W. Wood described his experiments (1899) in photographing sound waves using a chronophotographic camera (*Phil. Mag.*, Aug., 1899, and *La Nature,* Aug. 9, 1900). He also described the work of Toepler along similar lines.

But, as already stated, prior to the year 1900 no experimenter had succeeded in reproducing the photographed sound vibrations recorded by the various ingenious methods employed.

In that year Ernst Ruhmer of Berlin announced his "Photographophone," the first device successfully to reproduce sound photographed on film. Ruhmer's method is described in an article under his own signature in the *Scientific American* of July 29, 1901. He used a "speaking arc light" in conjunction with a microphone and transformer in recording, and an arc light in reproducing, the interruption of the light waves by the developed film being registered by an "exceedingly sensitive selenium cell connected with two telephone receivers in the circuit of a small dry battery." To direct the light beams he used a cylindrical lens and an optical slit.

In his announcement in the *Scientific American* Ruhmer stated that it was his intention to employ the Photographophone in connection with the cinematograph to ascertain, as he said, whether it was "possible to record the movements of bodies and sounds (such as

music) upon the same film." But he never attempted to carry his experiments further than the recording and reproduction of sound by photographic means and, as we know now, his "speaking arc" method could never have been successfully adapted for the talking picture.

It remained for Eugene Augustin Lauste, a Frenchman, who had received his early training in the laboratory of Edison, to be the first

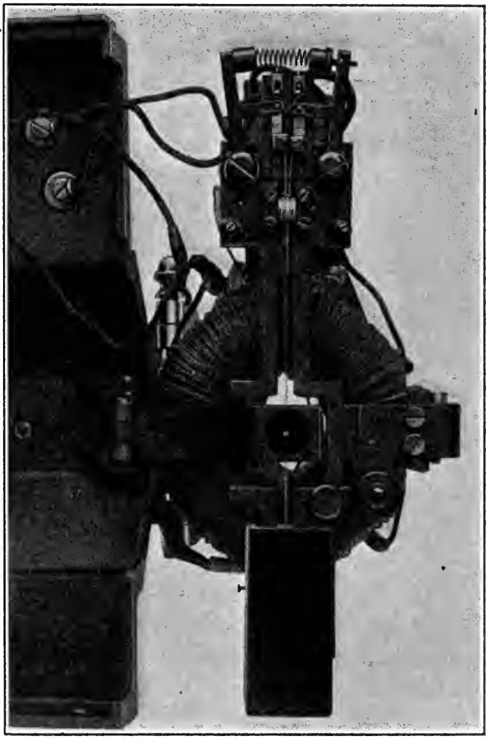

FIG. 2. The improved string recorder which Mr. Lauste used in 1912–13, a double string light valve, with which his best records were made. The records, as were all those made with the string recorder, were variable width records.

to record and reproduce sound and scene simultaneously and synchronously upon the same strip of sensitized celluloid and to disclose fundamental processes that are still embodied in present-day talking picture equipment.

Lauste first conceived his idea of photographically recording sound

pictures in the year 1888, when he read an account, published some years before in the *Scientific American Supplement* (May 21, 1881), of the invention by Dr. Alexander Graham Bell and Sumner Tainter of the Photophone. Lauste reasoned that if sound could be transmitted through space by means of radiant energy these electrical sound waves could also be recorded photographically and reproduced, using the selenium cell in the same manner as Dr. Bell had used it.

At first it was Lauste's idea to record the sound vibrations photographically on a ribbon or band of bromide paper and he hoped to find means to reproduce them, using a mirror and the reflection of light. About a year later, however, he first saw a specimen of Eastman's new film at the Edison laboratory, and realized that this phase of the problem did not require further consideration. The sensitized celluloid ribbon of Eastman furnished the ideal base for photographing sound as well as motion.

It was to be many years, however, before he could undertake his experiments in a practical way. He was first to become the inventor and designer of the Eidoloscope camera and projector, and the inventor of the so-called "Latham loop" and indispensable second sprocket, which are still essential elements in most modern projection machines, and which for years were a much-mooted factor in the patent litigation that marked the early history of the film industry.

Following his invention of the Eidoloscope camera he was associated with the American Biograph and Mutoscope Companies for several years, and it was not until the year 1900 that he was enabled to make his first grate light valve, parts of which are still in existence. But in the interval, he made many experimental drawings and designs which have for the most part, unfortunately, been lost.

In 1904 Lauste devised a crude apparatus to prove that sound could actually be photographed. He was then associated with William Kennedy Laurie Dickson, who had been his superior during the early days in the Edison laboratory, and he wanted to convince Dickson that his idea was practicable.

Lauste has stated that the device was little more than a toy—a box with a narrow slit behind which the film passed, a crank to wind the film, and an adjustment of a mirror fitted on a diaphragm which reflected light on the slit in response to the sound vibrations. In a way, the device was not greatly different from that used by Dr. Blake in 1878 in his experiments in photographing sound, except that Lauste used film instead of a sensitized glass plate.

It was sufficient, however, to prove to Dickson that Lauste's idea had possibilities and he directed Lauste to proceed with his experimental work. During the remainder of that year Lauste made several grate light valves and parts of a recording apparatus to run the film continuously, and also experimented with acetylene and incandescent lighting means.

In 1905 he built a complete experimental apparatus for recording and reproducing pictures and sound simultaneously on the same film at one operation. The sound waves were recorded as variations in

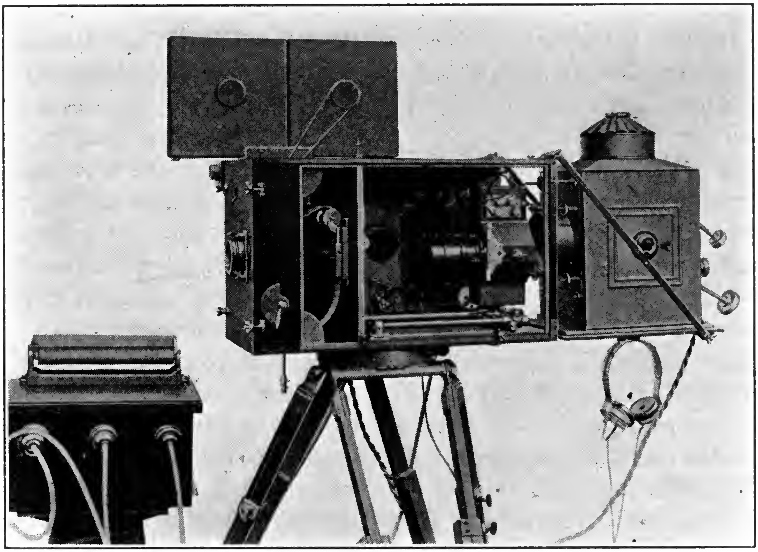

FIG. 3. Mr. Lauste's combined camera for sound and scene, employing the double string light valve; used by Mr. Lauste in 1912–13.

density and the results, it need not be added, were not highly successful. Nevertheless, crude as the device was, it reassured Lauste that if he was enabled to record the sound vibrations accurately he could also reproduce them.

In 1906, in association with an Australian experimenter named Haines, and John St. Vincent Pletts, a British engineer, he filed an application at the British Patent Office (No. 18,057) for "*A New and Improved Method of and Means for Simultaneously Recording and Reproducing Movements and Sounds.*"

Haines, Pletts, and Lauste, in the order named, were recorded as the inventors, but the inclusion of their names in the patent was unknown to Lauste until its issuance, and as thereafter in all the testimonies and published accounts of the invention their names do not appear, there seems to be no evidence that either of the co-patentees contributed anything to the invention that Lauste had not previously disclosed to others.

According to Lauste, himself, their association with him was simply for the purpose of securing for him the necessary capital to conduct his experiments, and when they failed to do so, neither had any further interest in the development of the invention.

In 1908 Lauste was enabled to secure the needed financial backing from Mr. George W. Jones, who was then the General Manager of the London Cinematograph Company, and in that year he visited Ernst Ruhmer in Berlin, with whom he had been corresponding for some time. He wished to study at close range the characteristics of Ruhmer's Photographophone and to ascertain whether the great German technician had made any further discoveries in the art of recording and reproducing sound. He soon satisfied himself that Ruhmer's method of recording and reproducing sound, using the so-called "singing arc' would never be suitable for talking pictures.

The difficulty of maintaining an "arc" of constant area limited this method so definitely as to make it quite impractical for talking picture purposes. Only when the flame was continuously elongated was the reproduction even moderately adequate.

In addition to this, the reproduction at best was very weak and uncertain, and it was only with difficulty that music or the voice could be heard in the ear-phones. Lauste purchased a Photographophone from Ruhmer and also a new selenium cell, the cell which he had been using previously, made by Bidwell in England, having proved unsatisfactory.

Lauste was using a mechanical slit at this time in all his apparatus, with a convex lens to concentrate the light rays. After his visit to Ruhmer he experimented with a cylindrical lens, but later used a larger convex lens for this purpose in all his experiments.

It is worthy of note that Ruhmer was very skeptical at this time as to the possibility of Lauste's successful reproduction of the sound recorded by his method for the reason that the natural inertia of his mechanical grate light valve was too great. The vibrations were too slow to record sound accurately and many sound cycles were missing.

Thus, the photographed sound waves when reproduced were inevitably greatly distorted and constantly interrupted.

The record of Lauste's work between 1908 and 1910 shows the logical development of his idea. Each partially unsuccessful experiment led naturally to the next. Nevertheless, at one point in his progress,

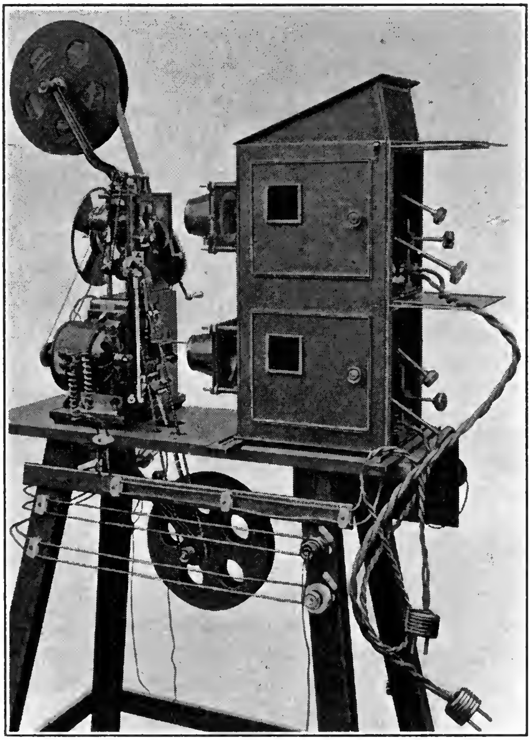

FIG. 4. Mr. Lauste's projector for sound and scene as completed and perfected by him in 1913. The picture is projected by means of the upper lantern, the lower lantern effecting the reproduction of sound. The light from the lower lantern passes through the film to the selenium cell on the front of the machine.

it is related, he despaired so of success in ever obtaining adequate results that for nearly three months he practically discontinued his experiments. Then almost by accident he hit upon the idea which at last assured him that his work had not been in vain, in his adaptation

of the diamagnetic wire acting between the poles of two strong magnets, which was to prove the solution of his problem.

In 1910 he had reached an *impasse* which he believed marked the end of all his painstaking efforts to record and reproduce sound on film successfully. In addition to Ruhmer, such distinguished scientific men as Marage of Paris, Blondel, and others of equal note, assured him that his efforts to reproduce sound by these methods would inevitably fail.

The London Cinematograph Company, which had supplied his scant capital, had got into financial difficulties and could no longer provide him with the means to continue his experiments. For days and weeks he racked his brains to find a method which would overcome the mechanical inertia that seemed to be an inescapable characteristic of his grates and light valves, but to little purpose.

Lauste, himself, has related how the idea which was to prove the answer to his problem, based on the principle of the string galvanometer, came to him in the early hours of the morning as he lay in bed. He arose forthwith, and at 2 A.M. was at work in his laboratory. In his first experimental recorder he used a silicon bronze wire because of its non-magnetic qualities, and his first attempt at reproduction of the record made with this instrument demonstrated that at last he was on the right track.

To record the progress of Lauste's experiments in their exact sequence is, of course, impossible, but in a general way the apparatus that he made tells its own story. In 1909 he constructed several types of grate light valves for mechanically recording sound waves. One was constructed on the principle of an electrical motor field in conjunction with an armature; another was a solenoid magnet—a plunger working within a hollow magnet; a third was a magnet and a diaphragm operating on the same principle as the telephone receiver.

This period constituted what might be called the first stage of his real progress and in 1910 he began experiments with a vibrating mirror, with which he obtained better, but still inadequate, results. During the early part of this year he also experimented with another principle of the light valve, using a solution of hydroxide of iron, based on the discovery of Majoranna in 1902.

Lauste's knowledge of chemistry, however, was too limited and he was unable to make the magnetic solution properly. He constructed the instruments but could not blend the hydroxide solution in its

proper proportions to get the results desired, so he discontinued his experiments along this line.

With his vibrating mirror he obtained better results than he had secured previously, but became convinced that this method would never be practical outside the studio or, at least, commercial, owing to the fact that the mirror recorded the vibrations of the camera as

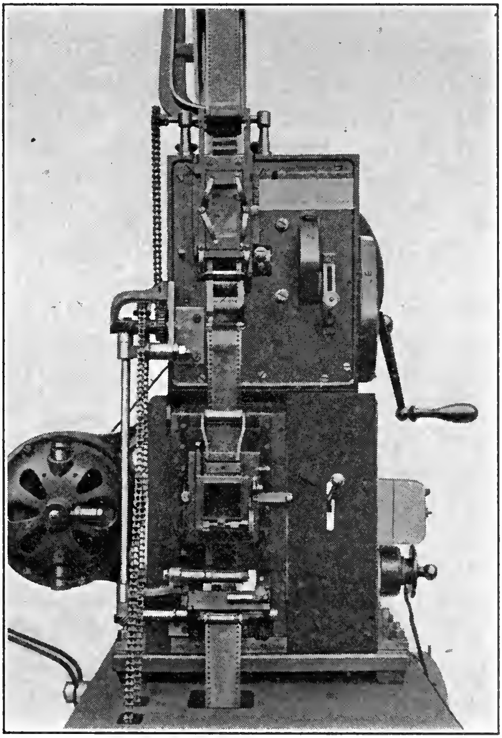

FIG. 5. A close-up of the projector mechanism, the upper part being the standard Pathé projector of the time, and the lower part the special Lauste sound reproducing equipment.

well as the sound waves which impinged on the microphone diaphragm. Lauste's experiments with his mirror recorder differ from those of previous experimenters, who, using similar means, had secured only a graphic curve of sound. He used, however, a *beam* instead of a point of light, and his negatives, of the variable area type, were half white and half black. It is similar to the method used by RCA

Photophone today. His experiments with the electrodiamagnetic recorder, as already described, were almost completely successful from the outset.

Lauste has related how, upon the day when he had completed his first mechanism of the string galvanometer type and had recorded a few words from a French gramaphone record on the film, he was still very dubious of success. Nevertheless, when he attempted to reproduce it and heard through the ear-phones a few words spoken distinctly, his amazement and delight knew no bounds.

By a curious coincidence the words which he heard, as reproduced from the French gramophone record, were "*J'entends tres bien maint*"—"I hear very well now". When he heard it, Lauste hardly believed his own ears. He called his wife and son to listen and then his assistants, one of whom, Mr. E. Sotain, who now resides at 39 Lonsdale Square, London, N. 1, has since told of this occasion. Sotain still recalls it vividly.

From this point on, Lauste's progress was very much more rapid. He devised several types of recording and reproducing apparatus using one and two non-magnetic wires in a magnetic field, several of which are still in existence and illustrate the ingenuity as well as the fine mechanical ability of the inventor. In 1910 Lauste also obtained a selenium cell from Bronk of Berlin, which gave him results far superior to those that he had previously obtained. This cell was in use by Lauste up to the time of the War.

Concerning Mr. Lauste's experiments in 1910, perhaps the testimony of Mr. L. G. Egrot, a member of the Society of Motion Picture Engineers, who personally observed his experiments, is of interest. His report was made at the request of Mr. Simon Rowson, as Chairman of the then British Section of the Society early in 1930. An extract from his report follows:

"I met Mr. Lauste in June, 1910, for the first time. He was introduced by Mr. Letuelle, French representative of the *Kinematograph Weekly* (the London film paper). I was then working on a colour patent which had been granted to me, and was very much interested in sound and synchronization of both sound and picture. When Mr. Lauste heard that I was going to London shortly, he asked me to make my trip coincide with his return, and we traveled together; as he was pleased to be with someone who knew something about the subject, he asked me to stop at his house instead of going to a boarding house, and there I stayed, with all his machines and experiments under my eyes.

"The old man had a workshop where he made his pieces of apparatus with his own hands, working on the patterns and fitting himself the most delicate pieces

of apparatus. Above his workshop, he had installed a small laboratory where his son Henry used to develop the tests of the films recorded. This recording business was taking place continuously and records of the variable density system were obtained of a consistent quality and capable of reproduction on a listening apparatus made by Mr. Lauste, where the light variations caused by the passing of the film at a constant speed acted on a selenium cell modulating the electrical flow in a telephone.

"The recording apparatus was at the time (June, 1910) working with a microphone, transformers, and a solenoid acting on a set of very light grids exquisitely balanced; these were placed in a beam of light, controlling the amount passing through a cylindrical lens which focused it onto the film which was ordinary cinematograph standard film, perforated, and moving at an even speed; and if I remember well, the taking speed was in the neighborhood of the speed adopted in our days.

"The results thus obtained were very promising. Listening to the music, *via* microphone, beam of light modulated by the grids, selenium cell, and telephone, was as good as listening through microphone and telephone only. But Mr. Lauste was not satisfied and, with a cabinet already packed with different recording machines, he was turning his attention to galvanometer oscillographs and, I must say, he even approached the possibility of using the light of Geissler tubes and the bending of cold light by electrical means.

"He had already started building his camera to take pictures and sound together, the front part of the camera allowing to test the different systems he was experimenting with for sound recording; he had already records on both principles, variable density and variable area.

"Naturally, I was very much struck with all this, and when I heard, after returning to Paris, that Mr. Lauste was in financial difficulties, I arranged with a friend of mine, Mr. Weiss, to supply him with further capital. And later we introduced another gentleman, Mr. Salomon, a Belgian broker, who entered into an agreement with him to improve his machines.

"Mr. Lauste was doing everything himself—designs, patterns for casting, all the delicate engineering and precision work, all electrical fitments, coils, transformers, *etc.;* experiments, testing, and work were of necessity very slow, although he used to be the first one up in the house and at work at six o'clock every morning, unless he happened to suffer from his leg, in which case he would take things easy and do lighter work. Very often on a Sunday, a bandmaster friend of his, Mr. Norris, would come along with his band and play in the garden of the house where, in 1911, Mr. Lauste had had a wooden building erected as an experimenting studio. The machine was taken out, with all leads, some picture would be made and some sound recorded.

"Things were thus proceeding, improvement after improvement being adopted after tests, when the war started. You know all the rest, even better than I do."

Lauste continued to develop his string light valve up to the outbreak of the War. Between 1910 and 1913 he photographed many thousand feet of film, some with sound records only, and some with both sound and picture. In 1911 he came to America on a brief visit,

chiefly in search of capital, with a combination camera and projector of a portable type which he had constructed to record and reproduce sound and scene.

He was able to make only a single experimental picture with this apparatus before being recalled to England, but this may be properly considered as the date when the first true sound picture was photographed in the United States. A short length specimen of this 1911 sound film is now in the museum of the Bell Telephone Laboratories.

Altogether Lauste designed and constructed at least six different types of his electrodiamagnetic recorder, on the principle of the string galvanometer. In some he used a single non-magnetic vibrating wire, in others two.

In the first string recorder he made, the single wire was held by spring tension. Later types employed bridges, and others an oil damper to absorb the secondary vibrations of the wire. His most satisfactory recorder, perfected in 1913, employed a double vibrating wire.

Lauste paid a second visit to Ruhmer in Berlin in 1912 to demonstrate his new method of recording sound waves photographically, and the German scientist, already stricken with the illness which caused his death the following year, was amazed at the clarity and distinctness of the record of a piano selection which Lauste made for him. For a time they considered continuing their experiments jointly, but Ruhmer's failing health would have made it impossible, even if it had not been impracticable for other reasons.

Lauste had brought his recording system to a point where but little further experimentation was needed, when the War came. He had then been experimenting for several years with various methods of amplification, using compressed air as its motive principle, as he felt then that all that was needed to make his sound pictures commercially available for public presentation was an adequate loud-speaking system.

England's entrance into the struggle between France and Germany definitely ended his experiments, and when he came to the United States in 1916 hoping to find capital for the commercialization of his invention, it was only to encounter a similar situation.

The experiments he carried on prior to 1913 in photographing sound and scene, however, furnish some of the fundamental processes of the art which we know today, and there seems little doubt but that future authorities will assign to Lauste a distinctive place in the long and distinguished list of pioneer inventors and experimenters whose work has helped to make possible the modern sound motion picture.

COMMITTEE ACTIVITIES

REPORT OF THE STUDIO LIGHTING COMMITTEE*

This Committee has met several times since the last convention, and a plan of operation differing from that followed in the past has been agreed upon. It was thought best, instead of recommending practices based on theory, to determine as far as possible what was being done in the foremost studios throughout the world. A canvass of the various manufacturers of incandescent lamps was also made in order to gather together standard specifications for the various sizes of lamps used in motion picture work; these specifications and dimensions are included in this report.

Questionnaires were sent to about one hundred studios throughout the world. Only a small proportion of these questionnaires have been returned, mostly from the large studios in Hollywood. From the data which are available the following facts were established:

(1) There are still in use in the industry a large number of arcs, amounting to 5 to 20 per cent of the entire equipment on hand.

(2) The current used for set lighting, per square foot of floor area within the set, varies from 50 to 150 watts per square foot.

(3) Photometers are not being used to measure light values on sets in spite of their great theoretical advantages. In all cases where light measurements are made on sets, a direct photographic method is employed, *i. e.*, a photographic test is made with a motion picture camera.

(4) No notable changes have been made in the past year in the type of lighting equipment used, but notable improvements have been made in the design of the equipment as far as its influence on sound pictures is concerned. Several types of equipment which are silent in operation have been developed, in which all cracking due to expansion of metal has been eliminated.

(5) Some question has been raised concerning the practicability of using alternating current for set lighting when producing sound pictures, because it might cause interference in the recording of the sound. A number of cases were reported where alternating current is being used for set lighting with absolutely no interference between the a-c. circuits and the sound recording circuits.

(6) Gaseous tubes are still used for lighting in special cases, but this type of light source has largely disappeared from the studios from which the questionnaires were returned.

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

(7) Arc lights are being used for color photography in about 60 per cent of the cases. The arc lamp is favored because its spectrum more nearly approximates that of daylight, and exterior shots can be more easily matched with interiors when this source is used.

(8) No radical improvements were reported in electrical apparatus for studio lighting.

(9) Lens apertures varying from $f/2.3$ to $f/1.8$ are being used in all cases reported.

The most notable advance relating to studio lighting since the previous report was the introduction of photographic emulsions of increased speed. New emulsions which recently have been put on the market are two to three times faster than those which have previously been in use. The effect of this on the amount of light used on sets has been already felt. In most cases no reduction in the *number* of units has been made, because it is still necessary to maintain a balance of lighting, but a reduction of the power rating of the lamps used in the various units has occurred and it is now possible to make a 400-watt unit do what a 1000-watt unit did before.

Lamp manufacturers undoubtedly will be asked to furnish units of lower power but of the same physical dimensions as the present types, in order to make them adaptable to existing equipment. An interesting sidelight on the sensitivity of the new film is the fact that "worklights" used to furnish light for the carpenters, *etc.*, must be extinguished during shooting. When using the slower film, the light from these lamps did not cause any appreciable effect.

As to future developments in the lighting field, it seems desirable that a lamp be made available which will be as simple, as light in weight, and as economical as the incandescent lamp, but which will have a spectral distribution more nearly approaching that of daylight. Considerable research and developmental work is being conducted along this line, but no solution of the problem has yet been reached. A light of this kind would be particularly suitable for color work.

ARC LAMP SOURCES

The use of electric arc lamps for studio lighting dates from the very beginning of the production of motion pictures indoors under artificial light. Early practice involved the use of ordinary carbon electrodes then commonly employed for arc lighting. Later, efforts were made to take advantage of special carbon electrodes impregnated with iron salts to produce a light rich in blue, violet.

and near ultra-violet, so as to meet the spectral requirements of the photographic emulsions then in use.

The introduction of the high-intensity arc as a brilliant source of energy in the region of the shorter wavelengths involved changes only in equipment design and methods of application, because the spectral distribution of energy closely paralleled the photo-sensitivity curve of the old emulsions.

It remained for the widespread adoption of panchromatic emulsions to bring about a change in the construction of carbon electrodes toward the end that those wavelengths (from the green to the red), hitherto considered to be of minor importance, are now favored to obtain a more evenly balanced distribution of energy within the

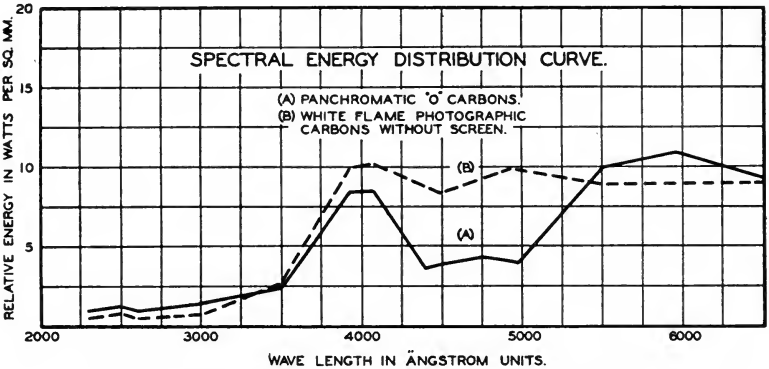

FIG. 1. Spectral energy distribution of panchromatic and white flame carbons without energy-convertor screen.

limits of the visible spectrum. Two outstanding examples of electrode construction in this respect are the so-called "panchromatic" and "white flame photographic" carbons. An analysis of the spectrum of both sources when operated in air shows each to be relatively weak in the middle ultra-violet beginning at about 2300 Å and rising slowly to about 3500 Å. Thereafter the rate rises rapidly to a peak at about 3900 Å, as in the case of all carbon arcs burning in air. From this point on, the spectral characteristics of both carbons are quite different. The panchromatic carbon drops to a secondary maximum in the blue-green and green between 4500 Å and 5000 Å, thereafter rising to an even higher peak in the yellow, orange, and red, between 5500 Å and 6500 Å. The white flame photographic carbon, on the other hand, maintains a fairly steady rate of energy emission

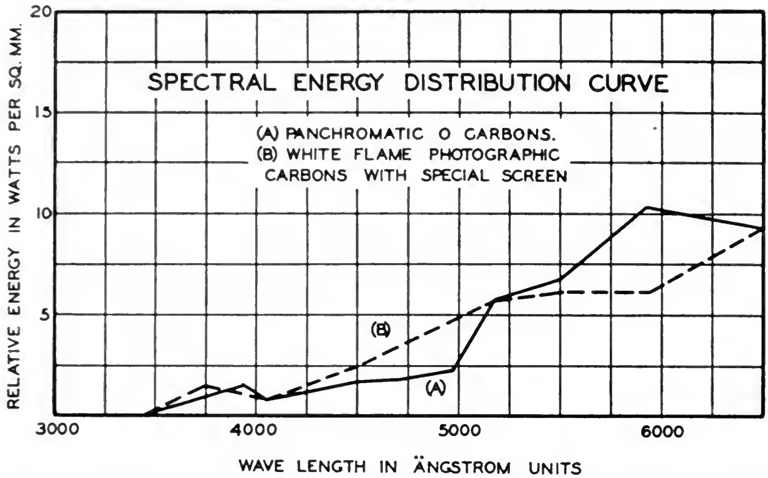

FIG. 2. Spectral energy distribution of panchromatic and white flame carbons with special screen.

from the peak at 3900 to approximately 6500 Å, with the exception of minor dips at 4500 Å and 6000 Å. Fig. 1 shows the spectral energy distribution for each type of carbon.

In an effort to further balance the spectral characteristics of the carbons against the photo-sensitivity of the panchromatic emulsions special energy-convertor screens are used. These screens completely absorb the energy of the radiation at wavelengths shorter than 3500 Å, and partially absorb it at wavelengths between 3500 Å and

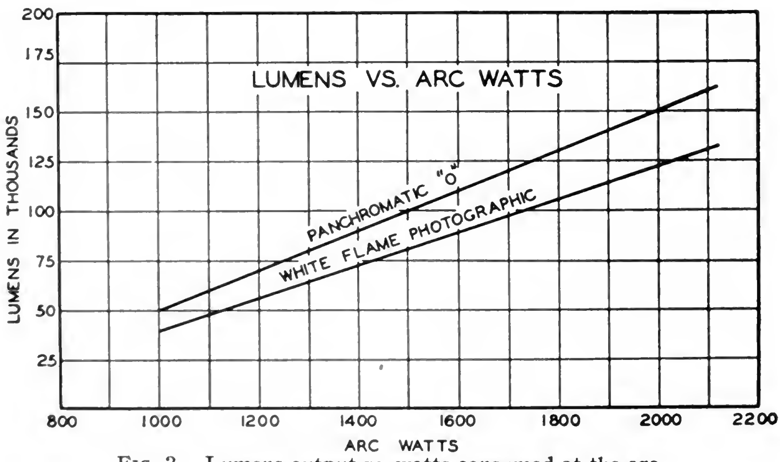

FIG. 3. Lumens output *vs.* watts consumed at the arc.

5000 Å. The spectral energy distribution of both types of carbons, when such a screen is employed, is shown in Fig. 2. Fig. 3 shows a graph of output lumens plotted against watts consumed at the arc, and Fig. 4 shows a graph of lumens per arc watt plotted against watts consumed by the arc.

GASEOUS TUBE LIGHT SOURCES

In considering light sources for motion picture photography a

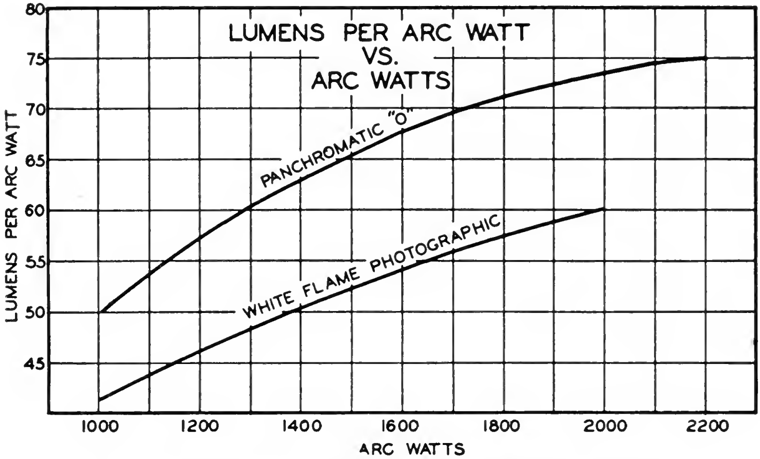

FIG. 4. Lumens per arc watt *vs.* watts consumed by the arc.

number of characteristics must be analyzed and properly evaluated. These are as follows:

(1) Color quality.
(2) Brightness per unit area of the incandescent element.
(3) Spherical distribution of the light flux.
(4) Light emitted per unit of power input.
(5) Practicability from the standpoint of control equipment, circuits in which it is to be connected, ruggedness, and dimming.

The film now almost exclusively used in motion picture photography is panchromatic in character, *i. e.*, sensitive to the entire visual spectrum. The present type of panchromatic film is more sensitive to blue and violet radiation and decreasingly sensitive to green, yellow, orange, and red. To secure correct orthochromatic rendering of colors in the positive print, light sources, radiating a relatively large percentage of red, orange, and yellow light as compared with blue, green, and violet, are necessary.

Motion picture sets are lighted by sources of two kinds: (1) by those possessing relatively low brightness and extended area, and (2) those having concentrated incandescent elements of extremely great brightness. The latter are generally employed in light projectors. Thus the brightness per unit area of the incandescent element of an illuminant is of importance in classifying it for a particular type of service.

The light distribution characteristic of a source vitally affects its application and controls its efficiency of utilization. The light obtained for a given amount of electrical power is as important as the ability to utilize that efficiency. Other factors being satisfactory, efficient sources are more to be desired than those of lower efficiency.

It is realized that the development of illuminants employing gas other than mercury vapor, is at a very early stage, and many of the characteristics shown below may change somewhat with increased knowledge of tube sources.

Characteristics of Several Gaseous Tube Illuminants[1]

Gas Employed		Characteristic Color of Light	Brightness in Candles per Sq. Inch	Efficiency in Lumens per Watt
Mercury Vapor arc		Blue-violet with green-yellow band	2.0	35**
Neon arc	High-current	Red	15.0	35**
	Low-current		2.0	
Helium		Purple	1.0	..
Carbon dioxide		Pinkish-white	0.20	3–5
Sodium vapor		Yellow	6.0	50**
Neon tube*		Red	0.25	..

It is desirable to include in this report some data on the photographic characteristics of the mercury vapor tube and the hot cathode neon arc[2] used separately and in combination. In the following table are given values of visual and photographic reflecting power for colored objects as measured under illumination from these sources. The values in the column designated as "visual" are the reflecting powers of various color panels as determined under sunlight illumination.

* As employed in sign lighting.

** Efficiencies under the most favorable circumstances, based on energy input to the tube and not including losses in control equipment.

Visual and Photographic Reflecting Power for Colored Objects as Measured under Different Illuminants

		Visual	Photographic Reflecting Power				
		R_v	Hg	Ne	3–1	2–1	1–1
71	Spectrum red	8.0	1.5	3.0	7.8	14.0	35.0
72	Vermilion	14.0	5.2	6.5	12.0	19.0	24.0
59	Vermilion orange	22.0	6.0	8.5	14.0	29.0	43.0
58	Cadmium orange	23.0	6.5	7.8	16.0	25.0	46.0
49	Cadmium yellow	36.0	8.5	11.0	21.0	29.0	54.0
51	Spectrum yellow	40.0	8.0	10.0	14.0	28.0	43.0
19	Chrome yellow DO	23.0	7.0	7.8	15.0	25.0	35.0
18	Chrome yellow orange	31.0	9.0	9.8	19.0	31.0	48.0
16T	Chrome yellow lemon, 50	51.0	13.0	16.0	22.0	35.0	48.0
107	Apple green	38.0	12.0	14.0	17.0	29.0	35.0
109	Emerald green	31.0	12.0	13.0	15.0	15.0	16.0
61	Cobalt green	17.0	11.0	9.0	12.0	13.0	10.0
60J	Viridian, 50	16.0	20.0	18.0	14.0	13.0	12.0
80W	Cobalt blue, 25	24.0	50.0	45.0	38.0	30.0	20.0
82E	Prussian blue, 25	9.0	18.0	17.0	16.0	15.0	15.0
83G	French ultramarine, 50	11.0	34.0	32.0	39.0	25.0	12.0
30	Ultramarine blue	6.0	18.0	17.0	14.0	10.0	5.0
64	Cobalt violet	9.0	32.0	26.0	30.0	32.0	30.0
65B	Spectrum violet, 12.5	8.5	20.0	18.0	22.0	20.0	18.0
95L	Purple lake, 50	8.0	14.0	12.0	16.0	14.0	16.0
96	Magenta lake	4.8	7.5	6.8	7.0	8.7	7.2
73A	Permanent crimson, 50	6.8	10.0	11.0	13.0	16.0	30.0

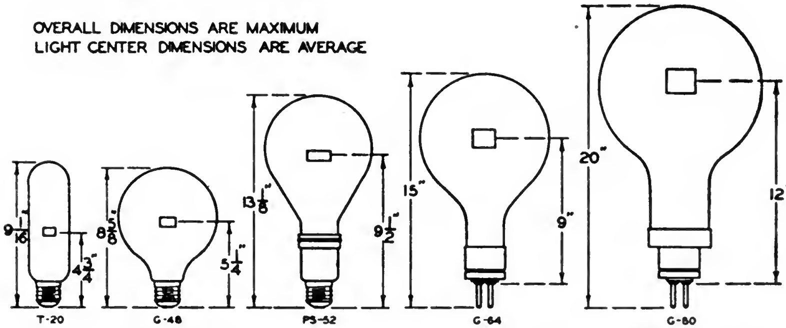

FIG. 5. Outlines and important dimensions of typical Mazda lamps used for studio lighting.

CHARACTERISTICS OF INCANDESCENT LAMPS

Physical Characteristics.—The lamp drawings in Fig. 5 and Fig. 5A show the dimensions of the various types in use and the design of the sockets.

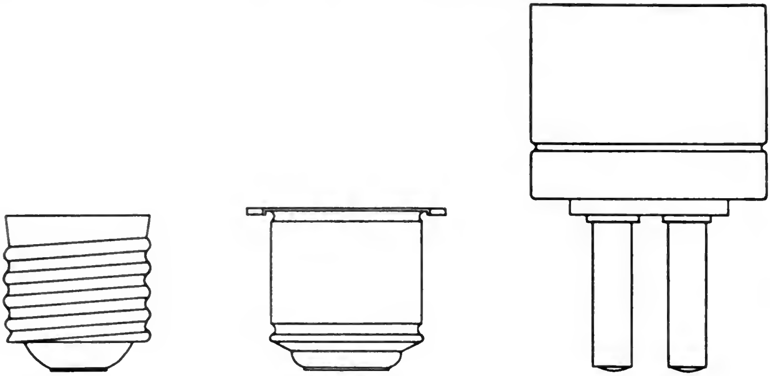

FIG. 5A. Typical lamp bases for studio lighting lamps.

Light Distribution.—The candle power curves in Figs. 6A, 6B, and 6C show the distribution of the light flux from each lamp.

Spectral Energy Distribution.—Table I shows the distribution of energy radiated by the filaments of Mazda lamps operating at various filament temperatures.

The curve of Fig. 7 shows the complete energy distribution for a lamp filament operating at about 2900°K.

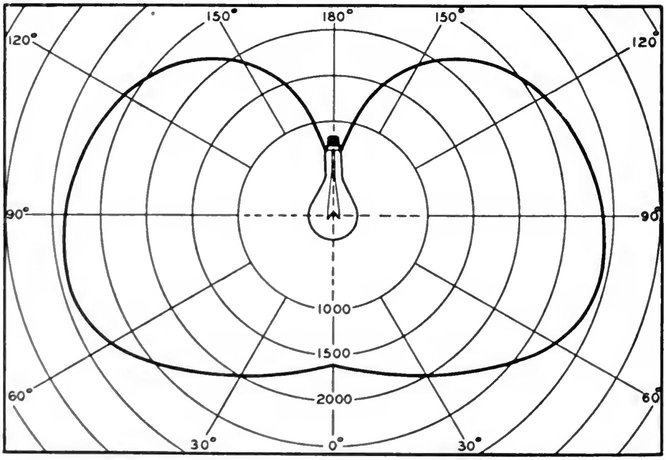

FIG. 6A. Average distribution of candle power in the vertical plane—1500-watt, 115-volt, PS-52 clear bulb standard Mazda lamp for general lighting service.

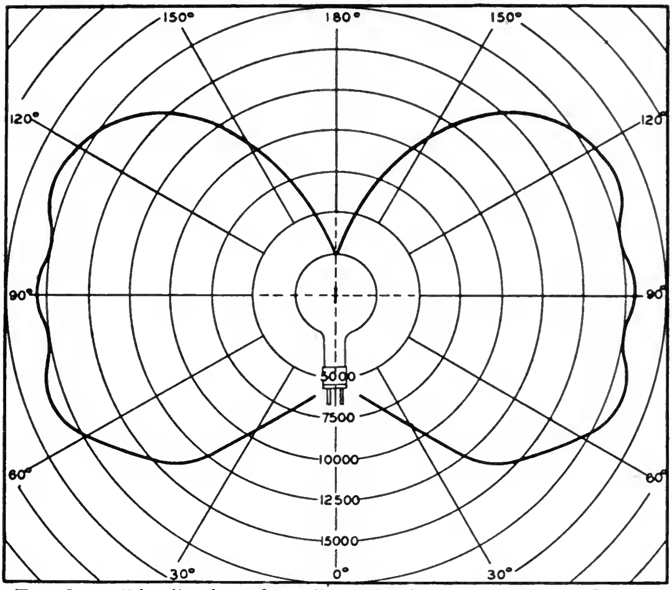

FIG. 6B. Distribution of candle power from a monoplane filament in a vertical plane perpendicular to the face of the light source—5000-watt, 115-volt, G-64 clear bulb Mazda lamp.

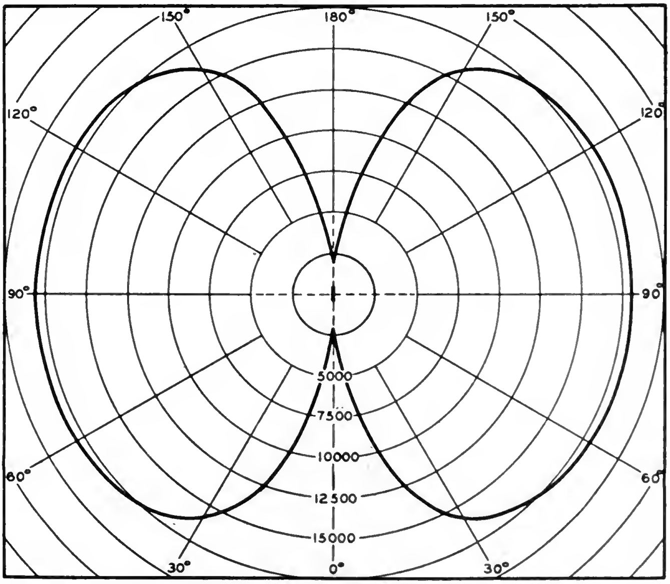

FIG. 6C. Distribution of candle power in the horizontal plane through the center of the filament of the 5000-watt, 115-volt lamp.

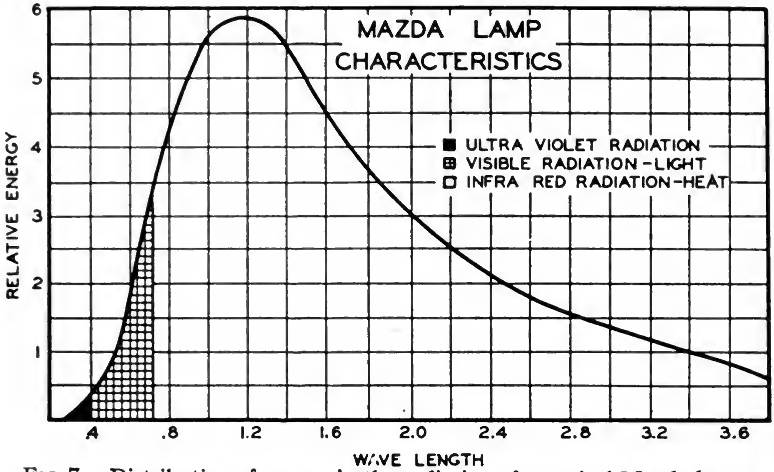

FIG. 7. Distribution of energy in the radiation of a typical Mazda lamp.

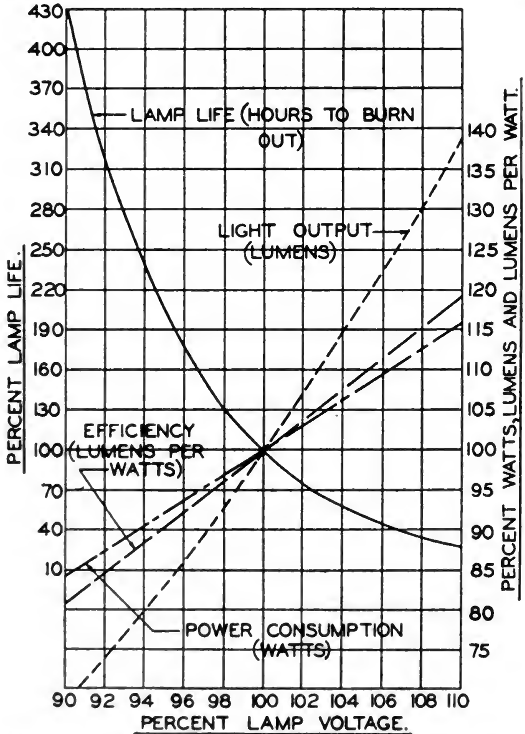

FIG. 8. Effect of voltage on Mazda lamp performance.

TABLE I

Spectral Distribution of Visible Radiant Energy from Incandescent Lamps

Wavelength	2900°K.	3000°K.	3100°K.
.40	.1306	..1492	.1688
.45	.2861	.3120	.3383
.50	.5066	.5326	.5582
.55	.7726	.7883	.8033
.60	1.0571	1.0523	1.0476
.65	1.3352	1.3014	1.2704
.70	1.5782	1.5193	1.4584
.75	1.8006	1.6969	1.6055

Voltage Effect on Mazda Lamps.—The curve of Fig. 8 shows the changes in lamp performance with changes in the voltage on the lamp. Note that an increasing voltage causes the light output to increase rapidly, and also causes a rise of filament temperature which changes the spectral distribution. The trend is indicated in Table I.

REFERENCES

[1] PARAFIN, M.: "Progress and Development Possibilities in Field of Luminescent Tubes," *M. T. Z.* (June 19, 1930), p. 889.

[2] JONES, L. A.: "The Photographic Reflecting Power of Colored Objects," *Trans. Soc. Mot. Pict. Eng.*, **XI** (September, 1928), No. 31, p. 564.

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REPORT OF HISTORICAL COMMITTEE

In view of the settlement by the courts of the high-vacuum electron tube patent situation and the intimate relation that this subject has to the talking picture, the following articles by Robert A. Millikan and William R. Ballard, published in the Bell Telephone Record of July, 1931, have been selected by the Historical Committee as being worthy of perpetuation in the records of the S. M. P. E.

RADIOS PAST AND FUTURE*

From a Radio Address by
ROBERT A. MILLIKAN

What is this miraculous thing, the radio, and how did it ever come into being? It is an altogether typical story of modern science, not of

* An abridgement of *Radio's Past and Future* by Robert A. Millikan. The complete address will be included in *Radio and Education*, The Proceedings of the First Annual Assembly of the National Advisory Council on Radio in Education, published by the University of Chicago Press in the Fall of 1931.

modern invention. Do not think for a moment that the radio was ever *invented*. It could not be. It has a long pedigree, as have all scientific advances. It grew step by step through the forgotten efforts of a long line of workers, few if any of whom could have been left out without causing the whole structure to collapse. I should like to tell the story backward, *i. e.*, to start at the very latest end of this long history, just as I, myself, have seen and lived through it, for this part of it is only twenty-one years old. It was in the spring of 1910, twenty-one years ago, that Dr. F. B. Jewett, an old friend and associate of mine at the University of Chicago from 1898 to 1902, and at that time transmission engineer of the American Telephone and Telegraph Company, came out to Chicago to see his former associates at the Ryerson Laboratory and said, "My superiors have informed me that we must if possible get a telephone line to San Francisco by the time of the World's Fair there in 1915, and I find that to give good service over such a huge distance we need to develop a telephone repeater which will transfer the spoken word undistorted from one circuit to another, just as the telegraph repeater makes such a transfer with dots and dashes, so that when the voice has become so weak through transmission over a long line as to be almost inaudible, it can be transferred to a new, fresh circuit and boosted up by it to the desired strength. Now such a device," said Jewett, "In order to follow all the minute modulations of the human voice must obviously be practically inertialess, and I don't see that we are likely to get such an inertialess moving part except by utilizing somehow these electron streams which you have been playing with here in your research work in physics for the past ten years. Cannot you let us have three or four research men from your laboratory, who are more or less familiar with all this electronic technic, let us take them into our employ and assign them the job of developing such a telephone repeater as I have been suggesting." I responded favorably, and in the fall of 1910 sent Dr. H. D. Arnold to the Bell Laboratories in New York for this specific purpose, and a little later others followed. These men, with others in the Bell Laboratories, developed or perfected, within the first two years of their intensive effort, three different successful telephone repeaters, all of them electronic, and these three, with one mechanical device of earlier origin, were given official tests which I, myself, went from Chicago to Philadelphia to participate in, in the early winter of 1914. The perfected de Forest three-electrode tube gave the best performance, and within a year of these tests a number

of such electron-tube repeater stations had been installed on the telephone line connecting New York and San Francisco, and the job which the telephone company had set had been accomplished. And today every time I telephone from Pasadena to New York I marvel at the flawlessness of the speech that has been thus relayed and amplified several different times before it reaches its destination, the voice quality usually being so perfect that I am unconscious that I am telephoning farther than to the adjoining room. At the time of this first test, too in 1914, the possibility, by the use of larger banks of such amplifier tubes and therefore larger energies, of shooting speech frequencies up into wireless antennas, already in use for dot-dash signaling, was realized, and a radio telephone station was soon hastily erected both at Montauk Point, Long Island, and at Wilmington, Delaware; and on Easter Sunday, 1915, in the midst of a terrific snow storm, this same group of men gathered at Montauk Point, shot up into the improvised antenna Lincoln's Gettysburg Address which rippled through the ether and was picked up two hundred miles away at the Wilmington station, and from there by connecting wire lines came back to us so that we could listen to it at Montauk. Later in 1915, by using still more powerful tubes and more of them, spoken words, shot up into the ether from the Arlington station, had been heard by some of the group sent to listen at the Eiffel Tower in Paris, and by one lone listener—Espenshied, who was listening at Honolulu with the aid of a receiving wire lying on a hillside six thousand miles away—and all the essential steps had been taken which made wor d-wide radio broadcasting of human speech a possibility.

I have thus told the story of the beginnings of speech broadcasting through the ether as I myself saw it. Completely unknown to this group until the spring of 1915, somewhat similar developments, at least so far as perfection of the de Forest three-electrode tube into a speech amplifier or repeater is concerned, had been going on in the laboratories of the General Electric Company at Schenectady. Who first made the three-electrode tube into a distortionless speech amplifier is not for our present purpose important—it has been decided differently by different courts.* But we are interested here only with

[1] At the time Dr. Millikan spoke these words the decision of the Supreme Court on the vacuum tube had not been rendered. A patent interference had been declared in 1916 between H. D. Arnold and Irving Langmuir. After various conflicting opinions by successive tribunals U. S. Patent No. 1,558,436 was issued to Langmuir in 1925. The question of priority of invention, "if invention was

the fact of the development or commercialization at about this time of a new scientific device and with its applications. The essential device, not only for the whole broadcasting art, and not only for most of modern long-distance wire telephony, but also for all forms of speech reproduction and amplification, and this includes the greater part of the whole modern motion picture industry—not to mention picture reproduction at a distance in all its forms—the essential underlying device for all this is simply one new instrument, the electron tube, telephone repeater, or amplifier. The multiplicity of the new and wholly unforeseen practical uses which one new device or principle introduced into physics seems invariably to find always astonishes even the physicist who alone realizes how small and often how simple is the fundamental scientific advance that has been made. Knock out that single instrument, the telephone repeater, and much of the whole structure of modern long-distance telephony, and practically all of radio and talking pictures, comes crashing to the ground.

THE HIGH VACUUM TUBE COMES BEFORE THE SUPREME COURT

WILLIAM R. BALLARD*

On May 25, 1931, the United States Supreme Court handed down an opinion disposing of a controversy in which the Telephone Company has been continuously involved since the year 1915, and in which Dr. H. D. Arnold, Director of Research of Bell Telephone Laboratories, has had a leading role. It concerned the patentability and the paternity of what is now commonly referred to as the "high vacuum" tube, used in radio and telephone work.

The Supreme Court held that the difference between the "high vacuum" tube and the earlier vacuum tubes of Fleming and de Forest

present," was continued, however, in the defense of the de Forest Radio Corporation to a suit for infringement of this Langmuir patent, brought by the General Electric Company in January, 1926. The District Court of the United States for Delaware, before which the suit came, held that the Langmuir patent was invalid for want of invention and novelty and because of prior use, and upon the ground that H. D. Arnold anticipated Langmuir. This decision was confirmed by the Circuit Court of Appeals for the Third District; and thereafter, upon a rehearing, reversed by a majority of that court which, however, did not mention the question of priority. Judge Woolley wrote a strong dissenting opinion in which he pointed out that Arnold's priority, among other things, made the patent invalid. The Supreme Court took the case up on writ of *certiorari* and on May 25, 1931, concluded that the Langmuir patent did not involve invention.

* American Telephone and Telegraph Co.

is not a patentable one, and it, accordingly, found the Langmuir patent of the General Electric Company on the high vacuum tube invalid. In doing this, it has confirmed the original view of Dr. Arnold and the Bell System patent attorneys at the time the high vacuum telephone repeater was first produced by Arnold in 1912 and 1913. It is interesting to note, moreover, that the Court's finding of unpatentability is based in large part upon the directness and facility with which Arnold reached his results in producing the telephone repeater at that time. The Court's opinion does not take up the question of priority as between Arnold and Langmuir because it was unnecessary to do so after finding the patent invalid. The facts in the record of the case, however, make it quite clear that Arnold was first, both in appreciating the advantages of a higher vacuum in such tubes and in actually producing the tubes themselves. Indeed, the last court to discuss and decide this question of priority so held; and the Supreme Court, in passing on the question of patentability impliedly gives Arnold a date for these accomplishments early in November, 1912.

While it would be difficult to overstate the credit that must be given Dr. de Forest for his invention of the three-electrode tube, the fact remains that the beginning of the revolution which his device has caused in modern communication and other industrial fields, dates from about the time when Arnold, fully conversant with the physical principles involved, had turned the de Forest tube into a commercially practical telephone repeater.

There is something of romance in the story of the development of the modern telephone repeater as well as in the marvels which the device has since wrought. It furnishes, moreover, a striking illustration of how intimately and directly the most abstruse scientific discoveries may affect commercial enterprises and rapidly change our daily habits. Scientists who had, prior to that time, been studying what went on inside an atom under the influence of heat and electrical charges, furnished the magic wand with which Arnold touched the de Forest audion and transformed it into a device which at once greatly extended the possibilities of communication and now daily performs miracles, alike for technician, schoolboy, and housewife.

In 1910, T. N. Vail, President of the American Telephone and Telegraph Company, promised those who were then planning the Panama-Pacific exposition that the Pacific Coast would have telephone communication with the Atlantic coast by the time the expo-

sition opened in 1915. This meant telephone communication over something like twice the distance then commercially practicable. It was a bold promise. Not only would it require the building of some thousands of miles of new telephone lines but it meant that there must be produced some altogether new instrumentalities not then even conceived. In particular, it required an entirely new form of telephone repeater—one that would be free from distortion so that a number could be used in series.

The promise was made largely upon the assurances of Dr. Jewett, then Transmission Engineer of the Telephone Company; and upon his shoulders was laid the burden of making good the promise. He began at once to select the men to do the work. As to the repeater, he believed that the solution would be reached only by the application of the latest developments of physical research to this specific telephone problem. He went to Dr. Millikan, then professor of physics at the University of Chicago, and already famous for his research work in the field of electron physics, and laid the problem before him. Dr. Millikan replied that he had just the man for the work—a young man named Arnold then working under him at the laboratories at the University; he was an expert in the field of electrical discharges *in vacua*. Arnold was employed, and early in 1911 he went to New York and was put to work in the laboratories of the Western Electric Company to produce a telephone repeater that would make possible transcontinental telephony.

After he had spent some time upon the problem and had perfected and patented a telephone repeater employing a column of mercury vapor, an incident occurred that changed the whole course of his plans. In October, 1912, Dr. Lee de Forest, then employed with the Federal Telegraph Company in California, came East in an effort to raise money for the rehabilitation of his own company. This he hoped to do by selling to the Telephone Company rights under his audion patents for telephone repeaters. John Stone Stone, formerly an engineer with the Telephone Company and a close friend of General Carty as well as of de Forest, introduced de Forest to the Telephone engineers and arranged for a demonstration of his audion as a repeater. The demonstration was made before Dr. Jewett and Dr. Colpitts on October 30th, in the latter's office on the 8th floor of the Laboratories building on West Street. The performance of the tube was far short of what they knew would be necessary for practical telephone repeater operation. Any attempt to handle loads compar-

able to those in commercial telephone circuits resulted in choking, blue glow, and unintelligible reproduction. Nevertheless, they were greatly impressed with the performance of the audion when the power level was kept low and the variations of the voice currents were small.

They arranged to have the demonstration repeated the next day with Arnold present. Thus, on November 1, 1912, Arnold first learned about the de Forest audion. He was, perhaps, more impressed than his associates, for his training had equipped him to appreciate the possibilities of this device as few others could have done. He understood at once the reason for the difficulties experienced at the higher power levels, and then and there he named the cure. He explained that the trouble was due to the erratic effects resulting from gas ionization within the tube occurring at the higher voltages; and that a commercially successful telephone repeater could undoubtedly be made from the de Forest audion by such a thorough removal of the gas that the action would be purely electronic.

It was this ready and perfect appreciation by Arnold of possibilities dormant in the de Forest audion, which resulted in the creation of the high vacuum telephone repeater, destined not only to revolutionize the communication art itself, but to develop entirely new industries.

It is interesting to note how thorough was Arnold's acquaintance with the principles involved even at that early time. Colpitts, misled by statements made in a then recent paper by an engineer of another organization, questioned whether, if the gas were removed, the electrons would get out of the filament at all, and whether if they came out, they would not all rush across the space under the slightest plate voltage, thus keeping the power output of the tube too low to be useful. Arnold assured him that the electrons would be emitted without the presence of gas and that, because of the "space charge" effect, which he explained to Colpitts, a considerable voltage would be required to get the desired current across the tube.

Arnold's grasp of the situation and his conviction as to the possibilities of the audion so impressed his superiors that he was at once given the job of converting the audion into a commercial telephone repeater. To make the tube a commercial repeater, it was necessary not only to improve the vacuum but to improve the mechanical structure of the tube as well, to perfect better and longer-lived filaments and make the internal impedances such as to match the telephone apparatus.

Exhaustive tests were then made to determine the operating characteristic and efficiency of the audion. In December, 1912, Arnold worked out mathematically the theoretical $^3/_2$-power law covering the relation between current and voltage in such tubes, assuming the absence of gas ionization, and found that some of his experimental data conformed closely to this theory. His study of the "Efficiency of the Audion" made in December, 1912, was a mathematical ascertainment of the law of third-electrode control of an electron stream. It was the first definite analysis ever made of the principle upon which the three-electrode tube produces its remarkable results. At the same time Arnold had his assistants working on new filaments and on the tube structure, devising new tools, perfecting themselves in the technic of tube manufacture and exhaust, and collecting the necessary equipment for manufacture of commercial repeaters.

On at least three occasions while Arnold was thus remaking the audion into a telephone repeater, he produced high vacuum tubes of the kind which the Langmuir patent afterward purported to cover; once in November, 1912, when he effected a "clean-up" in one of the original de Forest audions upon which he was performing tests, again in April and May of 1913 when trying out the new Gaede molecular pump ordered for use in manufacturing the repeater tubes, and again the following autumn when the first tubes to go into use were made.

A license under the de Forest patents was secured in July, 1913, and the manufacture of tubes for commercial telephone use began shortly thereafter. A field trial of high vacuum telephone repeaters under commercial service conditions was begun October 18, 1913, at Philadelphia on the New York-Washington telephone lines. In the summer of 1914 these repeaters went into the new transcontinental telephone line, and with the official opening of the line in 1915, President Vail's promise of 1910 was fulfilled.

It was not until after the improved tubes had gone into commercial use that it occurred to Arnold or the Patent Department that an application for patent should be filed, and then only because they learned that the General Electric Company was attempting to patent such tubes in the name of Langmuir. Convinced of his own priority, Arnold then, upon advice of counsel, filed his application, so that the patent should issue, if at all, to the first inventor. However, Arnold and his counsel were so convinced that the subject matter was not of a patentable nature, that they afterward made a strong effort in the

Patent Office to have both applications rejected upon this ground, before the taking of testimony as to priority. As noted, the Supreme Court's decision comes as a confirmation of their original views as to patentability.

ABSTRACTS

A 35-Mm. Portable Sound-Film Projector. H. Griffin. *Mot. Pict. Proj.*, **IV**, July, 1931, p. 24. While designed primarily as a portable unit, this equipment has an optical system said to be equal to those used in theater outfits and there is nothing to prevent its use in any moderate sized auditorium. For this purpose it would be used with a 900-watt, 30-volt projection lamp and transformer. Any amplifier can be connected to the equipment, and the reproduction is stated to be at least equal to that obtained in first class theaters at the present time. A. A. C.

A Portable Non-intermittent Cine Projector. *Brit. J. Phot.*, **78**, June 19, 1931, p. 362. Gaumont has demonstrated a fully developed portable cine projector with continuous film movement. It employs multiple lenses on the periphery of a cylindrical drum which is free to rotate on its axis and is made to turn by the motion of the film. The light cone from the film plate is reflected by a prism system back through 360 degrees to the objective, and to the projection screen. A. A. C.

The Silent Mitchell Camera. William Stull. *Amer. Cinemat.*, **12**, July, 1931, p. 9. An illustrated description of the latest Mitchell product, expressly designed for talking picture use. "It is not perfectly noiseless, yet the nearest thing to perfect silence that has yet appeared." The movement is much simplified, the dissolving shutter is eliminated and the adjustable shutter is placed much nearer the film than on previous models. The camera has no turret, the lens being fitted to a large slip-mount of standard design, to which any modern lens may be fitted. Focusing is done from the rear of the camera and the objective lens mounts are so made that the lens does not rotate during this operation. A. A. C.

Photographic Lens Tests. W. B. Rayton. *Amer. Cinemat.*, **12**, July, 1931, p. 11. A projection method of testing photographic lenses is described, which consists of recording on a panchromatic plate the projected image of a small round aperture located at any selected point in the image plane. This reversal of object and image planes, for testing purposes, results in a negative whose defects are magnified and can easily be seen; the method is said to be free of all the uncertainties of the ordinary camera tests. The illustrations show the defining power of several different standard makes of lenses. A. A. C.

Are Stereoscopic "Movies" Possible? Frank Fowell. *Mot. Pict. Proj.*, **IV**, August, 1931, p. 11. The principal methods of securing stereoscopic effects on the screen are enumerated and discussed. Ives' recent work with multiple projectors and special screens is not mentioned, and the article closes with an expression of doubt as to the possibility of a commercial solution of the problem. A. A. C.

Wide Image from Standard 35-Mm. Film. *Mot. Pict. Proj.*, **IV**, August, 1931, p. 19. This article describes the Fulvue process—which has occasioned much favorable comment in England—with a sketch showing the optical system

and illustrations of the results obtained. It is a cylindrical lens system designed to magnify the scene in the horizontal plane only, and is used in both camera and projector. The sketch shows an auxiliary lens of four elements, which would indicate a loss in illumination of at least 32 per cent both in photography and in projection. A. A. C.

Sound Equipment Sales Abroad. C. J. NORTH AND N. D. GOLDEN. *Electronics*, July, 1931, p. 11. An analysis of the market for sound picture equipment in all the principal countries throughout the world. According to the authors, there are some 37,000 motion picture theaters outside the United States, 12,000 of which have been already wired. Of the remainder, only approximately 4000 represent a potential market for sound equipment.

The article contains much valuable information on foreign competition, tariffs, credits, patents, and methods of establishing foreign contacts. A. C. H.

Electronic Musical Instruments. R. RAVEN-HART. *Electronics*, July, 1931, p. 18. Principally a description of the "Tratonium" invented by Dr. Trautwein of the Radio Research section of the Berlin Academy of Music. In this instrument, the fundamental frequency is generated by an oscillating neon lamp and the quality is adjusted by a filter circuit. A. C. H.

Phototube Circuit Design for Sound Pictures. C. A. WYETH. *Electronics*, July, 1931, p. 22. Concerned primarily with the characteristics of phototubes and the method by which they are coupled to an amplifier. A. C. H.

Electroöptical and Magnetoöptical Phenomena in Relation to Sound Recording. A. LOVICKI. *Technique Cinemat.*, **2**, May, 1931, pp. 15–22. The principle of application of the electrical bi-refringence phenomenon, as used in the Kerr cell for modulation of a light beam, is discussed. This type of cell is used by Tobis Klangfilm. Another phenomenon, that of rotatory polarization in a magnetic field, is described as representing possible usefulness in modulating light for sound recording. C. E. I.

Purported Disadvantages in Desensitizing. C. EMMERMANN. *Filmtechnik*, **7**, Apr. 4, 1931, pp. 5–6. Mention is made of the claims of P. V. Neugebauer and H. Windisch that the use of pinakryptol green as a desensitizer decreases the emulsion speed to one-fourth or one-fifth the original speed. This claim was immediately refuted by Lüppo-Cramer. Further work by K. Jacobsohn and H. Dürr has shown that bathing in a preliminary bath of pinakryptol green has the effect of decreasing the gamma for a given time of development so that an increased time of development is required to give a gamma equal to that of the untreated film. With films developed to equal gammas, the maximum loss in threshold speed was found to be 4° Eder-Hecht. This slight decrease has practically no significance even when films are badly underexposed. Also, for the films developed to equal gammas, the gradation shown in the higher exposures of the H & D curve was slightly improved when pinakryptol green was used. Emmermann has made tests using the instructions of Jacobsohn and Dürr with orthochromatic film of high gamma properties and an MQ developer. The results of these tests show a decrease of gamma for a given time of development, the decrease being proportionally greater for the shorter times of development. An average decrease in threshold speed of 2° to 3° Eder-Hecht and a maximum decrease of 4° Eder-Hecht were found. The slight decrease in threshold speed is only perceptible with grossly underexposed films. The use of pinakryptol

green was found to have no effect upon the shape of the characteristic curve. L. E. M.

Spicer-Dufay Color Film Process. A. PEREIRA. *Kine. Weekly*, **171**, May 28, 1931, p. 49. Describes a demonstration of a three-color screen process and a visit to the manufacturing plant where the film is made. It is stated that 1000-foot lengths of film, nearly 2 feet wide, are ruled with a three-color screen so that about a half million squares cover each frame of 35-mm. film. An aceto-cellulose support is first prepared to receive the screen mosaic. A coating of collodion, stained green, is put on the base and a greasy ink resist applied to the surface by means of an engraved steel roller. A bleaching bath then destroys the green dye where it is not protected by the resist. After a wash, the film is treated in a red dye solution which produces a series of red lines between the green lines. The resist is then removed and a new one added crosswise of the red and green mosaic. The film is next passed through a final bath of blue. When the resist is removed the film is ready for preliminary treatment previous to coating with a panchromatic emulsion. It is stated to be possible to make satisfactory duplicates. G. E. M.

Synchronous Negative and Sound Track Rewinder. *Sound Waves*, **5**, June, 1931, p 6. Describes a rewinder for cutting the two negatives made by a bi-pack process and the accompanying sound negative to match an accepted positive. Four reels are mounted on a common shaft (hand cranked) at one side of the cutting bench, and a similar group on the other side. A bank of four sprockets is mounted in the center, over which the films pass. All four films are wound in synchronism until the first splice is reached on the positive. The negatives are then cut, if necessary, and a similar practice is followed throughout the editing of the entire reel. G. E. M.

Analyzing Theater Acoustics Electrically. *Mot. Pict. Herald*, **103**, Sect. 2, June 6, 1931, pp. 48–50. Describes a reverberation meter for the measurement of the rate of sound decay. Sound energy is converted into electrical energy and a series of points is recorded on the surface of a waxed paper drum which gives graphically an exact history of the sound decay from which the reverberation time may be determined. The meter has found extensive application in connection with the study of the acoustics of theaters, studios, broadcasting rooms, *etc.*, and offers a means for correcting acoustic defects.

A sound meter is also described which was designed to record the effect of sounds in terms comparable with the loudness sensations judged by the ear. It consists of a microphone, an amplifier, a weighing network, indicating meter, and the necessary battery supply. The meter scale reads directly in decibels. The amplifier is adjusted so that its sensitivity is greatest near a frequency of 2000 cycles per second. A level recorder may also be substituted for the visual meter. Either broad band analyses or single frequency analyses may be made. G. E. M.

Western Electric Theater Horns. *Mot. Pict. Herald*, **103**, Sect. 2, June 6, 1931, p. 54. The exponential type of horn, used in conjunction with a suitably designed receiver, is considered the most satisfactory for theater use. Several types of exponential horns, available commercially, are described. These types are classified into two groups: (*a*) curling and (*b*) folding. Combinations of the two groups are also known. A shallow type for installation in narrow stages

has also been designed, which consists of two horns opening into a common mouthpiece. G. E. M.

Reversing the Slope of the Main Floor of a Theater. G. SCHUTZ. *Mot. Pict. Herald*, **104**, Sect. 2, July 4, 1931, p. 12. Commenting on the paper by B. Schlanger (*J. Soc. Mot. Pict. Eng.*, **XVII** (Aug., 1931) No. 2, p. 161) on this subject, it is stated that the scheme suggested restricts the width of the auditorium close to the limitations of the angle of good vision. Another effect of the scheme would be a substantial reduction of the angle of projection. A considerable change in the design of the decorative treatment of the theater would also be necessary with a probable decrease in the "grandiose" type of "exotic ornamentation." The design is considered a hopeful one, however, in keeping with the character of the motion picture itself, which is a radical departure from the world's previous art-forms. G. E. M.

The Measurement of the Output of Amplifiers. P. HATSCHEK. *Kinotechnik*, **13**, March 20, 1931, pp. 112–114. The "Audimeter" is an instrument for measuring the output of amplifiers in order to suit the power delivered to the loud speaker to the size and acoustical properties of the theater. The output is measured under conditions that simulate practice. M. W. S.

The Measurement of the Sensitivity of Photographic Emulsions. L. LOBEL AND M. DUBOIS. *Kinotechnik*, **13**, April 20, 1931, pp. 142–146. The relative speeds of a number of photographic plates and of three kinds of motion picture negative film were determined from strips exposed in a Scheiner sensitometer and developed to a constant gamma of 1.6. These speeds were expressed in terms of the relative exposures required to give the same result, and were expressed according to the following four systems: (1) The Hurter and Driffield system based on the inertia point; (2) the Labussière system based on the value of 0.5 for the least useful gradient of the density *vs.* log exposure curve; (3) the system of Jones and Russell, a variation of No. 2, but based on the value 0.2; (4) the Scheiner system, based on the threshold value. The relative exposures thus determined were compared with each other and with the relative exposures required under practical conditions in the camera to attain the same rendering of shadow detail in the negatives. The shadow rendering was judged from positive prints on paper. The authors conclude that, taking the exposure of the fastest plate tested as the unit according to each system, the exposure required according to the practical test is the longest. The exposure according to the H & D system comes next for normal emulsions. The differences between the results of the H & D system and the practical determinations are within the experimental error of the practical method. (These conclusions are based on what appears to be a purely arbitrary assumption; *viz.*, that the exposures required for the standard emulsion according to the practical method and according to the sensitometric methods are equal.—Abstractor.) M. W. S.

Slow Motion Investigations. W. ENDE. *Kinotechnik*, **13**, April 20, 1931, pp. 139–142, and May 5, 1931, pp. 158–161. A number of industrial applications of slow motion photography are described. These include investigations of typewriters, gasoline engines, relay contacts, ticket printing machines, thermal regulators, and electric arcs. Various operating defects were studied and overcome. M. W. S.

The Annual Technical Report of the A. E. G. for 1930. A New Re-recording

Apparatus. *Kinotechnik*, **13**, April 20, 1931, pp. 150–151. In a re-recording apparatus for sound film, the sound film is uniformly unrolled, and the sound record is transferred to a phonograph disk by means of a photocell, amplifier, and stylus. A multiple synchronizing apparatus serves to synchronize music, noises, *etc.*, taken on separate films with dialog. Three films pass through the apparatus simultaneously so that the synchronization can be recorded on a fourth film or on a disk. M. W. S.

Synchronization. L. KUTZLEB. *Kinotechnik*, **13**, May 5, 1931, pp. 163–165. Three systems for synchronizing speech and pictures are in use in Germany.

In the "Rythmographie" system, a moving film conveys the printed words before the eyes of the speaker, the time being indicated by the passage of a mark by the word in question.

The system of R. Thun employs a similar device to aid the speaker, but also provides for comparing the sound record and the picture and making corrections automatically in a printing process. Cutting of the negative is thus avoided.

The Czerny system makes the picture visible to the speaker and provides him with the original text through head phones. M. W. S.

A Method for Determining the Shape of the Curve of a Variable Width Sound Record. L. WEINGLASS. *Kinotechnik*, **13**, May 5, 1931, p. 162. The curve of a sound record with a frequency of 7000–8000 becomes very difficult to follow by optical means in the direction of the motion of the film. The author proposes to move a narrow beam of light of definite length across the sound records, *i. e.*, at right angles to the visual slit image. The variation in the integrated transparency is expressed as a function of the curve of the sound record. M. W. S.

Measuring Instrument with Photocell. *Kinotechnik*, **13**, May 5, 1931, pp. 166–167. The measuring instrument built by Gans and Goldschmidt, and including a photoelectric cell and Mihaly circuit, is said to have been improved to facilitate measurement of screen brightness. The cell has been made movable with respect to the moving coil galvanometer case, without danger from external fields, by placing the electrostatically sensitive part of the Mihaly circuit in the cell container. The cell is fitted with an iris diaphragm and shutter. M. W. S.

New Incandescent Lamps for Motion Picture Projectors for Amateur and Professional Film. *Kinotechnik*, **13**, May 5, 1931, pp. 167–168. A description and drawings with dimensions of the Osram projection lamps. M. W. S.

Lenses of Large Aperture in Motion Picture Photography. K. KÖFINGER. *Kinotechnik*, **13**, May 20, 1931, pp. 178–180. Charts are reproduced showing the depth of focus at different focus settings and diaphragm openings for the 50-mm. Biotar $f/1.4$ and the 35-mm. Plasmat $f/2$ lenses. Some of the advantages and disadvantages of large aperture lenses are discussed. M. W. S.

Closing of the Eyelids and the Viewing of Motion Pictures. G. KÖGEL. *Kinotechnik*, **13**, June 5, 1931, pp. 191–192. A discussion of eye-strain in the viewing of motion pictures as caused by the various involuntary movements of the eyelid and eyeballs. It is considered that sound films strain the eyes more than silent films. M. W. S.

The Applicability of Selenium Cells for Sound Film. Compensation Methods for Attaining Straight Line Reproduction. F. O. ROTHY. *Kinotechnik*, **13**,

May 20, 1931, pp. 175–177. On account of the lack of sensitivity of a selenium cell at the higher frequencies, it is necessary to introduce some form of compensation into the circuit. The introduction of a condenser into a resistance coupling gives a nearer approach to a straight-line reproduction but does not give full correction. Also, there is a considerable reduction of amplitude at all frequencies. By the introduction of several tuned oscillatory circuits into various stages of amplification, the overemphasized frequencies may be damped, and straight-line reproduction attained. The output from a selenium cell with a hook-up of this kind is said to be about 200 times greater than that from a photoelectric cell combination. It is claimed that high-efficiency speakers can be operated with a selenium cell and three stages of amplification. M. W. S.

The Determination, by the Use of the Watkins Factor, of the Necessary Development Time to Attain a Definite Gamma in a Used Solution. L. Lobel and M. Dubois. *Kinotechnik*, **13**, June 5, 1931, pp. 196–197. Working with Kodak duplicating film and Kodak fine grain developer, the authors found that differences in temperature and extent of exhaustion have no marked influence on the gammas attained with a given Watkins factor. With increased bromide in the developer, higher gammas were obtained with the same factor. It is recommended that the Watkins factor be used in practice to attain definite gammas. Since the greatest difficulty lies in judging the exact time of appearance of the image, a strip of film with a standard exposure should be placed in the developer along with the film to be developed, and the time of appearance judged on the strip. M. W. S.

The Preservation and Treatment of Films in School Cinematography. W. Rahts. *Internat. Rev. of Educational Cinemat.*, **3**, April, 1931, pp. 339–351. Unfortunately, many of the films used in school motion picture programs, for either education or entertainment, are on nitrocellulose base, being either ordinary commercial films, or teaching films printed on nitrate base. On combustion of this film, under average conditions, quantities of the poisonous gases, carbon monoxide, oxides of nitrogen, and hydrocyanic acid are formed, so in the event of fire on the school premises, the lives of many children would be endangered. The rules of the German X-Ray Society and those of the National Fire Prevention Association for the storage and handling of photographic films are given in detail, and their application to schools is explained. One important consideration is that all rooms or cupboards must be arranged to open to the outer air on the accumulation of a small internal pressure.

The deterioration of film from causes other than fire, such as excessive drying, scratching, and other mechanical injury is discussed. The proper technic of projection, rewinding, inspecting, and handling is described. A properly treated print on nitrate film should last for 100 or 120 projections. H. P.

Cinematography and Culture. W. Günther. *Internat. Rev. of Educational Cinemat.*, **3**, April, 1931, pp. 319–338. A comprehensive discussion of films as educational accessories. From the standpoint of the services they render to the community, films are classified as follows: (1) propaganda films; (2) instructional films; and (3) entertainment films. The newsreel and the animated drawing are stated in an editorial commentary to have displaced films of a documentary or educational character. It is suggested that sound films of the

scientific type should be prepared as a valuable educational feature of present-day programs. G. E. M.

Some Tentative Standards for City Visual Education Programs. E. R. ENLOW. *Educational Screen*, **10**, June, 1931, p. 167. The result of a questionnaire sent from the National Academy of Visual Instruction to city directors. An empirical equation has been deduced for the average number of staff members of an adequate department, *viz.*, $Y = \dfrac{x}{30{,}000 + 0.03x}$ where Y = number of staff members and x = population of city. Each adequately supplied school building should possess about $1000 worth of visual equipment with a conservative range of from $600 to $1400. The cost per pupil, in an adequate program, would be 60 cents per year or with a possible range of 30 to 90 cents. Other facts of value in planning such a program are given. R. P. L.

Performance of Output Pentodes. J. M. GLESSNER. *Proc. I. R. E.*, **19**, No. 8, Aug., 1931, p. 1391. This paper compares a group of experimental pentodes with corresponding triodes. Four principal factors are considered, namely: power output, distortion, power sensitivity and a-c./d-c. power economy. Generally it was found that the a-c./d-c. power economy and the power sensitivity of the pentode is higher than that of the corresponding triodes. Harmonic distortion appears to be worse with the pentode and the variation in power output with variation in load resistance is shown to be practically the same for both types of tubes. The article is illustrated with various curves supporting the results obtained. A. H. H.

ABSTRACTS OF RECENT U. S. PATENTS

1,812,865. **Valve for Magazines for Picture Films.** A. DINA. Assigned to The Precision Machine Co., Inc. July 7, 1931. Entrance valve for film leading to a film magazine for preventing fire from following the film from the projection machine into the film magazine in the event of accident. The valve consists of a pair of heat conducting rollers, mounted adjacent to a pair of guide rollers at the entrance of the film magazine. The rollers form a narrow entrance slit for the film with respect to the magazine and quench fire from the film in case of accident by conducting away heat as rapidly as it is generated.

1,812,957. **Electrically Operating Sound Recorder and Reproducer.** C. HUENLICH. Assigned to Thomas A. Edison, Inc. July 7, 1931. An electromagnetically actuated stylus for cutting a sound groove in a cylindrical type sound record. The stylus is carried by a floating arm which is connected with an armature. The armature is electromagnetically vibrated by an electromagnetic driving unit for cutting a sound groove in the cylindrical wax record by correspondingly moving the stylus according to impressed sound vibrations for producing a "hill and dale" sound groove in the sound record.

1,813,000. **Photographic Film Printer.** F. B. THOMPSON. Assigned to Cinema Patents Co. July 7, 1931. A multiplicity of film printer units are connected together for permitting a multiplicity of positive prints to be made from a single negative while insuring the obtaining of a uniform light intensity at the point of exposure in each of the film printer units in accordance with the light intensity desired or required for the production of the positive from the negative in accordance with the scene passing through the unit. A battery of photographic film printer units is provided and the negative film driven through all the units. Each unit has a positive film passing therethrough which is printed from the negative film by printer mechanism disposed in each of the printer units.

1,813,204. **Radio Photography Transmitter.** V. A. SCHOENBERG. July 7, 1931. Scanning mechanism for a moving film in which each frame of the film is successively scanned. The scanning disk is mounted in alignment with the film and is so shielded that a single light beam passes therethrough in the course of its passage through the film. A framing structure is provided around the light aperture through the scanning disk and is adjustable for defining the active field of the scanning disk.

1,813,439. **Lens for Photographic Cameras, Picture Projecting Apparatus, and Other Like Optical Devices.** CLYDE J. COLEMAN. July 7, 1931. Lens for obtaining sharper definition of objects which includes a marginal stop formed with an aperture and a supplementary stop of smaller diameter than the aperture located near the surface of the lens remote from the source of light and in a plane between the marginal stop and the focal plane near the optical axis. The supplementary stop is adjustable toward or away from the marginal stop. With this arrangement an image of the objects on the optical axis and near it or the meridian on which the screen is situated is projected by those rays reflected therefrom that

pass through the aperture constituted by the marginal and central stops to the lens while the rays of light reflected from other objects in the field pass obliquely through the said aperture to portions of the lens determined by the position of each such object.

1,813,542. **Talking Picture Vehicle.** F. H. OWENS. Assigned to Owens Development Corp. July 7, 1931. A portable talking picture apparatus in which the sound reproducer and picture projector is mounted upon a vehicle. The rear of the vehicle is provided with doors which may be swung open to support the picture projection screen and to provide a mounting for loud speakers on the rear of the doors. The reproduced sound and pictures are thereby made available to observers from the rear of the vehicle. The projection apparatus is located inside the vehicle. The idea is to provide a talking picture apparatus which can be readily moved from place to place for exhibitions at county fairs and in open air places.

1,813,669. **Method of Making Color Photographic Film Embossing Tools.** H. E. HASTINGS. Assigned to Eastman Kodak Co. July 7, 1931. Tool for embossing minute lenticular elements in a film through which light rays pass to the light-sensitive emulsion. The tool consists of an extra hard drawn phosphor bronze member with a smooth accurately dimensioned periphery which is highly polished. There are a plurality of closely spaced serrations in the order of 0.001 of an inch in size cut in the polished periphery. A thin layer of chromium is disposed on the polished serrations. These serrations are pressed into the film thus forming the lenticular elements through which light rays may pass.

1,813,681. **Electron Tube with Slotted Anode for Light Source in Reproduction.** O. SANDVIK. Assigned to Eastman Kodak Co. July 7, 1931. The electron tube in the reproducing amplifier has its anode slotted to enable the light radiations to be directed outwardly from the cathode and upon the photoelectric cell in the sound reproducing circuit, with a film having a sound record thereon interposed in the path between the source of illumination and the photoelectric cell. The sound record on the film modulates the photoelectric cell circuit. This arrangement eliminates the necessity of an extra light source and thus reduces the size of the sound reproducing apparatus.

1,813,990. **Film Spool.** H. A. DEVRY. Assigned to Q. R. S. DeVry Corp. July 14, 1931. The side plates of the film spool are each provided with tongues which project inwardly into grooves in the drive shaft and serve as keys for insuring simultaneous rotation of the film spool with the shaft.

1,814,137. **System for Multiple Scanning of an Area for Each Rotation of Disk.** J. B. FELSHIN. July 14, 1931. A system of scanning disks wherein a pair of coaxial parallel disks are arranged each having a plurality of spaced elongated narrow openings arranged in annular aligned paths. One of the disks has a greater number of apertures than the other disk. The arrangement of apertures is such that scanning of a predetermined area is effected a plurality of times during each revolution of the disks.

1,814,181. **Laminated Scanning Device.** L. OSKOW. July 14, 1931. Scanning means for a television system where the scanning device consists of a laminated member with a shutter movable with respect to the laminated member. The laminated member comprises a series of parallel plates spaced one from another.

The shutter is formed with a narrow slit disposed at an angle to the openings and allowing scanning of large areas in great detail.

1,814,217. **Changeover System Employing a Single Source and Lens.** T. HILL. July 14, 1931. The focusing equipment of the projector is mounted upon a frame adapted to receive the film driving mechanism. The projectors are adapted to be moved into alignment with a single source of light and a single lens as the end of each reel is reached and preparatory to the projection of the succeeding reel. Because of the fact that the same light source and same lens system is employed for each projection mechanism, refocusing of the machine is not necessary and the display of the picture can be handled by one operator without interruption.

1,814,382. **Television Receiving Apparatus.** V. G. GUSTAFSON. July 14, 1931. The rays of light from the glow discharge tube at the receiver are converged to a single beam or point of light which is directed against a revolving wheel having a number of reflecting surfaces thereon in the path of the converged light beam and arranged in such position as to reflect the light beam onto a second revolving wheel having similar reflecting surfaces on the same. The second revolving wheel is arranged with its axis approximately perpendicular to the axis of the first wheel and is so disposed as to reflect the received light beam to a screen for forming the frame. An objective lens may be employed to enlarge the pictures projected to the screen.

1,815,105. **Cylindrical Scanning.** W. HOWEY. July 21, 1931. The same cylindrical device is simultaneously used for scanning and engraving any desired subject. The cylindrical device produces rotary motion of a connected cylindrical surface and simultaneously produces coördinate movement of the scanning and engraving means adjacent the latter. The system may use any desired form of scanning by reflected light, mechanical means, or otherwise; it may utilize any desired form of engraving apparatus and may have more than one cylinder and its engraving device mechanically connected to the scanner.

1,815,513. **Manufacture of Cellulose Films.** H. KRULL. Assigned to The Film Feldmuhle, Papier und Zellstoffwerke Aktiengesellschaft. July 21, 1931. Manufacture of cellulose films of any desired length from aqueous cellulose solutions, preferably from a viscose solution, in which a plurality of tanks and a plurality of transport rolls are provided, each tank having coördinated therewith one of said transport rolls having a smoothly polished surface. Individual adjustable drives are arranged for a number of the transport rolls whereby shrinkage of the film may be compensated for by appropriate adjustment of roll speed. A viscose pouring device is disposed in coöperative relation to that transport roll which is the first in the series of rolls. There are two idle rollers between each two adjacent transport rolls in the series of the rolls. One of the idle rollers is adapted to take off the film from one roll of the two and the other idle roller is adapted to receive the film and transmit it to the second one of the adjacent transport rolls. The film is passed through the baths so that one and the same surface of it only is subjected to the action of such baths, and its opposite surface is maintained smooth by contact with the polished surfaces of the rolls.

1,814,525. **Continuous Printer.** F. H. OWENS. Assigned to Owens Development Corp. July 14, 1931. Apparatus for the printing at high speed of positive from a negative motion picture film and including guiding and driving means,

whereby the printing operation may take place during the continuous and uniform movement of the positive and negative film strips. A feed member consisting of a circular rotary disk is provided having peripheral teeth acting on a negative film at one side and on a positive film at the other side. Curved film guides serve to support the films in driving relation to the feed member and independently thereof. The radius of the arc of the film guides is greater than that of the feed member. There is a lens between the films adjacent the feed member. A light source is arranged outside the negative film and in alignment with the lens. Printing of the positive from the negative occurs as the films are moved in opposite directions around the rotary disk.

1,814,588. **Still Picture Projector.** R. P. VAULT. Assigned to Society for Visual Education, Inc. July 14, 1931. A projector employing film for the reproduction of "still" pictures. The film is of an endless arrangement adapted to be moved past the optical projection path and rewound for a repeat operation. The film is mounted inside the projector adjacent the hinged side thereof. The film is threaded through a single twist by which the surface of the film directly faces the door of the projection machine when the door is closed. A claw device extends through the door and engages the film permitting it to be moved step by step from the exterior of the cabinet to align selected frames with the optical system.

1,814,672. **Color Motion Picture System.** M. B. DUPONT. Assigned to Max B. DuPont Vitacolor Corp. July 14, 1931. Process of color photography and system of projection upon a screen for reproducing pictures in color without the disagreeable fringe effects or flicker often encountered in motion pictures which are reproduced in color. A combined shutter of opaque portions and color filters is employed where the filters comprise two color units each having major filters whose color values are from the same side of the spectrum but whose color vibrations are of different wavelengths and an interposed filter from the opposite side of the spectrum whose effective color vibration is less than that of the major filters. Successive frames of the negative film will be impressed with a blended color mixture. The light rays acting upon an image area are limited to a series of non-complementary and complementary spectrum values and a following area to a second series so combined as to run approximately from one side of the spectrum to the other, whereby the optical persistency of color of the first series will combine with the persistency of the second series and furnish all the spectrum values.

1,814,701. **Method of Making Viewing Gratings for Relief or Stereoscopic Pictures.** H. E. IVES. Assigned to The Perser Corp. July 14, 1931. The grating is made by exposing a light-sensitive plate to a substantially punctiform light source. The light rays are passed through a grating complementary in its spacing to the grating used in taking the relief picture negative. The distance between the light source and the complementary grating bears the same ratio to the distance between the grating and the light-sensitive plate, as the distance between the taking grating and the lens of the camera which made the picture to be viewed bore to twice the distance between the taking grating and the negative plate when the picture was made.

1,814,861. **Sound Recording and Reproducing Apparatus.** J. F. SEES. Assigned to General Electric Co. July 14, 1931. An adjustable slit for a sound reproducing projector is provided in a supporting housing aligned with the sound

track on the film. The slit has end shutters so mounted that the shutters may be separately adjusted in an endwise direction for widening or narrowing the light slit which is passed through the film.

1,814,987. **Color Picture Transmitting System.** A. WEAVER, *et al.* Assigned to American Telephone and Telegraph Co. July 14, 1931. Method of producing colored pictures where a colored object is progressively analyzed for each of a plurality of primary colors A separate series of electrical impulses corresponding to the varying values of one of the primary colors is transmitted to a distant point. Each of the separate series of impulses is utilized at the receiver to produce corresponding separate primary color records, which when used together produce a picture of the original object in its original natural colors. The invention contemplates the transmission of the different color components over different wire circuits, each of which is designed for the transmission of the particular series of impulses inherent in the transmission of the particular primary color allotted to that particular signaling channel.

1,815,109. **Machine Serving to Determine or Verify the Position of the Filament of an Electric Lamp.** A. J. B. MARSAT. July 21, 1931. A light source is arranged in the path of two separate optical systems. The position of the filament in the electric lamp is verified by focusing the image of the filament through the two separate optical systems upon a screen and the position of the filament in the lamp thus determined.

1,815,203. **Transmitting Dot Image of a Picture.** H. E. IVES. Assigned to Bell Telephone Laboratories, Inc. July 21, 1931. A dot image of a picture is produced by exposing varying portions of successive elemental areas of a record blank. A light-refracting device is used for staggering the elemental areas of the picture for forming the reproduced pattern. The selection of code combination of telegraphic signals is depended upon for producing the dot pattern at the receiver. The code telegraph signals may be transmitted directly to a station at which the picture is to be reproduced or they may be punched in a tape and subsequently transmitted. The received code telegraph signals control the punching of the tape. The elemental areas of a light-sensitive picture-receiving surface are exposed in succession along linear elements to a beam of light, with respect to which the light-sensitive surface is moved, for the purpose of reproducing the picture in the form of a dot image.

1,815,208. **Stereo-Cinematographic Camera.** H. MORAZ. July 21, 1931. A stereo-cinematographic camera in which a pair of spaced reflecting prisms are arranged to receive the rays of light angularly on one of the faces and to reflect the rays right toward the space between the prisms. A second pair of right reflecting prisms is disposed between the first pair to reflect the received images backward, and a right reflecting prism is provided adjacent the back of the second pair of prisms and turned obliquely to bring the received images one above the other. Two objectives are arranged to receive the images from the oblique prism. The film is moved perpendicularly to the plane of the rays of the objectives and the true position of the right and left portions of the picture reproduced.

1,815,251. **Method of Producing Animated Motion Picture Films.** F. L. GOLDMAN. Assigned to Audio-Cinema, Inc. July 21, 1931. Animated pictures are produced by a method which consists in providing a series of base pictures on a transparent film and manually executing on sheet material adapted to be posi-

tioned in front of a camera a series of pictures of a moving object in different positions upon a materially larger scale than the base pictures and providing each with a dark, blank background. A corresponding companion series of dark silhouette pictures of the object of the same size as said object picture is drawn and in the same respective positions on the sheet material and providing each with a light blank background. The base of the picture is placed with an unexposed negative film in a camera, with the base film in front of the negative film, and both back of the camera lens. The silhouette pictures are successively placed in front of the camera lens and photographed in reduced size upon the negative film through successive picture areas of the transparent base picture film. The base pictures are printed by reflection of light from the light, blank backgrounds of the silhouette pictures, whereby the base pictures will be projected upon the negative film with a portion of each negative picture area corresponding in outline with the dark silhouette, left unexposed The base film is now removed from in front of the negative film and the pictures of the object placed with the dark background successively in front of the camera lens and photographed in reduced size upon the unexposed portion of successive picture areas upon the negative film. The process is intended to reduce the labor of making animated pictures and render the making of such pictures commercially profitable.

1,815,455. **Using Principle and Secondary Images for Avoiding "Jerky" Pictures.** F. WALLER. Assigned to Paramount Publix Corp. July 21, 1931. A motion picture film having a plurality of frames where each frame bears images of successive phases of action of a subject. The images on each frame are of different degrees of intensity to provide a principal image and a secondary image, the principal image on one frame appearing as a secondary image on a succeeding frame. The purpose is to avoid the jerky and unnatural movement of the images in reproduction of the pictures. If five images are to be exposed they may be exposed respectively $^1/_{10}$, $^2/_{10}$, $^4/_{10}$, $^2/_{10}$, and $^1/_{10}$ of the normal exposure period. The motion picture positive produced by the method described will show upon projection a natural movement of the character desired.

1,815,481. **Automatic Switching Mechanism for Recording or Reproducing Apparatus.** F. H. OWENS. Assigned to Owens Development Corp. July 21, 1931. An automatic switching mechanism is provided for rendering the motors and the recording or reproducing lamp inoperative while the film is being threaded through the camera or projector. The switch mechanism is operated while the film retaining means is shifted out of engagement with the film moving means during the process of threading up. After the film has been threaded through the mechanism adjacent the light station, the film retaining means is shifted into engagement with the film moving means and the circuits to the driving motors and lamps completed.

1,815,486. **Film Viewing Machine.** I. SERRURIER. July 21, 1931. A film is moved past a viewing aperture by a driving motor mounted in compact assembly in a casing which also contains a lamp for illuminating the film. The film is moved under the guidance of a pair of rail members which presses the film against the light aperture for permitting the successive frames of the film to be viewed in step-by-step order. The step-by-step movement which is imparted to the film is applied by the movement of a sprocket actuated by the driving motor.

1,815,692. **Film Recording System Employing a Stylus.** F. VON MADALER.

Assigned to Visionola Mfg. Corp. July 21, 1931. A stylus device is mounted adjacent a film strip and operates to directly record sound vibrations adjacent one edge of the film strip. The recording needle is mounted in connection with a system of weights which serve to substantially eliminate and absorb undesired mechanical vibrations while permitting the sound vibrations to be recorded on the sound strip preparatory to a reproduction process in which the record formed on the film serves to vibrate a reproducing stylus for actuating a sound reproducing diaphragm.

1,815,693. **Synchronizing Mechanism for Disk Reproduction.** A. DEMADALER. Assigned to Visionola Mfg. Corp. July 21, 1931. Picture projection and sound reproducing unit wherein a Geneva movement is connected between the driving motor shaft and a driven shaft imparting intermittent movement to the film feeding drum while continuous movement is imparted to the record table which carries the phonograph record. The motion pictures are displayed on a small screen located at a point where the sounds emanate from the loud speaker which is operated from the phonograph.

1,815,694. **Synchronously Operated Motion Picture and Sound Reproduction Apparatus.** A. DEMADALER. Assigned to Visionola Mfg. Corp. July 21, 1931. A unit apparatus for reproducing sound and projecting motion pictures which includes a turntable drive for a phonograph which is operated in synchronism with the driving mechanism of the picture projection apparatus for effecting the reproduction of sound in timed relation to the projection of the picture. The same motor which drives the phonograph turntable also drives the picture projection apparatus with a gear system interposed therebetween for insuring synchronized operation of both the picture and sound reproducing systems.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

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M. W. PALMER, Paramount Publix Corp., 35–11 35th Ave., Long Island City, N. Y.
L. C. PORTER, General Electric Co., Nela Park, Cleveland, Ohio
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CONTRIBUTORS TO THIS ISSUE

Chambers, G. A.: Born May 30, 1905, at Rochester, N. Y. B.S. in Physics, St. Lawrence University, 1926; research laboratories, Eastman Kodak Company, 1926–29; motion picture film department, Eastman Kodak Company, 1929 to date.

Crawford, M.: Born November 13, 1880, at New York, N. Y. Engaged in newspaper, magazine, and publication work on Pacific Coast and New York City, 1899–1913. Director of publicity, Mutual Film Corp., Metro Pictures Corp., Fox Film Corp. Editor of various trade publications. Research work, Bell Telephone Laboratories, Inc., 1927 to date.

Griffin, H.: Born February 11, 1887, at London, England. Sales engineer, American Motion Picture Machine Company, 1908–12; traveling representative, Nicholas Power Company, 1912–17; engineer in charge, Motion Picture Division, Y. M. C. A., Siberia, 1917–19; development engineer, Nicholas Power Company, 1919–22; general sales manager, Nicholas Power Company, 1922–25; general sales manager, International Projector Corporation, 1925 to date.

Hickman, K.: Born 1896 at London, England. Chemist, Royal College of Science, 1916; research, Poison Gas Station, 1916–19; research, Color Photography, 1919–21; demonstrator, Royal College of Science, 1921–25; chemist, Eastman Kodak Company, 1925 to date.

Huse, E.: Born 1897 at Newburyport, Mass. George Washington University, 1918; research laboratories, Eastman Kodak Company, 1919–26; motion picture film department, Eastman Kodak Company, 1926 to date.

Jones, L. A.: See May, 1931, issue of JOURNAL.

Polderman, L. H.: Born May 30, 1894, at Rotterdam, Holland. Construction department, Carrier Engineering Corporation, 1918–25; Pacific Coast sales manager, Carrier Engineering Corporation, 1925 to date.

Sanford, C. R.: Born 1903 at Taunton, Mass. B.S., Worcester Polytechnic Institute, 1927; research chemist, Eastman Kodak Company, 1928 to date.

Simonds, A. H.: Born 1904 at Boston, Mass. B.S., Massachusetts Institute of Technology, 1925; engineering and sales departments, Carrier Engineering Corporation, 1925 to date.

Weyerts, W. J.: Born 1903. B.S. and M.S., University of Denver. Chemist, American Smelting and Refining Company, 1926; chemist, Great Western Sugar Company, 1926–29; chemist, Eastman Kodak Company, 1929 to date.

SOCIETY ANNOUNCEMENTS

FINANCE COMMITTEE

President Crabtree has appointed a new Finance Committee with the following personnel:

W. B. Cook	W. C. Hubbard
J. I. Crabtree	L. A. Jones
H. T. Cowling	L. C. Porter

The functions of the Finance Committee are (*a*) to make recommendations to the Board of Governors with regard to investment of the Society's funds; (*b*) to report on committee budgets, and to submit a yearly budget for the Society's operation; and (*c*) to recommend ways and means of increasing the funds of the Society.

EXHIBIT OF HISTORICAL APPARATUS

As a result of the efforts of Mr. W. E. Theisen, the Chairman of the Subcommittee on Exhibits of the Historical Committee, an extensive exhibit of apparatus of historical interest has been placed on exhibition in the Los Angeles museum. A full description of this exhibit will appear in a future issue of the Journal.

INTER-SOCIETY COLOR COUNCIL

Under the auspices of the Optical Society of America, a meeting of the Inter-Society Color Council was held in New York on February 26, 1931. The meeting was attended by representatives of many national societies who are interested in various ways in the subject of color specification. The S. M. P. E. was represented by Dr. H. M. Moyse and Mr. R. M. Evans, who were recently reappointed by President Crabtree to represent the Society again at the organization meeting at the Museum of Science and Industry, New York, N. Y., on September 21, 1931. This meeting will also be attended by appointed delegates from national societies and associations interested in the standardization, description, and specification of color.

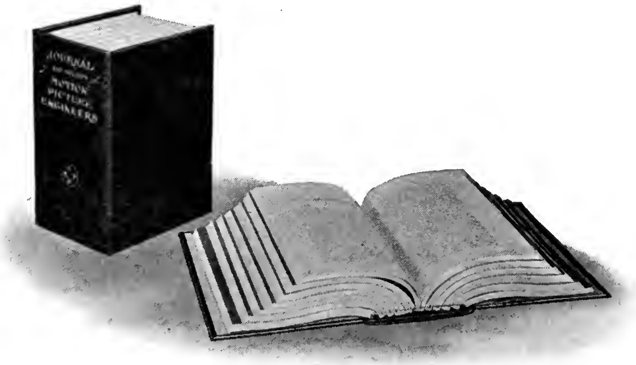
It is felt that at the moment the color specification of standard light sources for sensitometric work and general light sources for studio use is of chief interest to this Society. When and if color photography becomes a more important factor in the industry, this interest will, of course, be extended to include the standardization of light filters, *etc.* Delegates to the Council will report later on the proceedings of the meeting.

President Crabtree has been appointed a member of the National Committee for Unemployment Relief by Mr. W. H. Hays who is chairman of the committee appointed by President Hoover.

The function of the committee is to develop and execute plans for the relief of unemployment in the motion picture industry and to coördinate with the various authorized local relief agencies.

JOURNAL BINDERS

The binder shown in the accompanying illustration serves as a temporary transfer binder or as a permanent cover for a complete

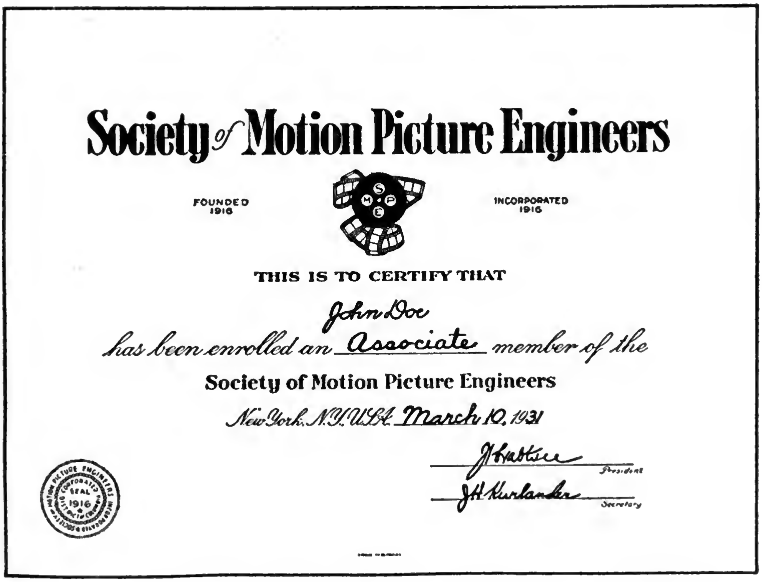


year's supply of JOURNALS. It is made of black crush fabrikoid, with lettering in gold. The binder is so constructed that each individual copy of the JOURNAL will lie flat as its pages are turned. The separate copies are held rigidly in place but may be removed or replaced at will in a few seconds.

These binders may be obtained by sending your order to the General Office of the Society, 33 West 42nd Street, New York, N. Y., accompanied by a remittance of two dollars. Your name and the volume number of the JOURNAL may be lettered in gold on embossed bars provided for the purpose at a charge of fifty cents each.

MEMBERSHIP CERTIFICATE

Associate members of the Society may obtain the membership certificate illustrated below by forwarding a request for the same to the General Office of the Society at 33 W. 42nd St., New York, N. Y., accompanied by a remittance of one dollar.


Society of Motion Picture Engineers

FOUNDED 1916 INCORPORATED 1916

THIS IS TO CERTIFY THAT

John Doe

has been enrolled an Associate member of the

Society of Motion Picture Engineers

New York, N.Y. U.S.A. March 10, 1931

President

Secretary

The Society regrets to announce the death of Donald F. Whiting, September 7, 1931.

PAPERS PROGRAM, FALL 1931 CONVENTION

MONDAY, OCTOBER 5TH

8:30 A.M.—Convention Registration.

9:30 A.M.—Convention Called to Order (*Ballroom, New Ocean House*).

Address of Welcome by President K. T. Compton, Massachusetts Institute of Technology, Cambridge, Mass.

Response by the President, J. I. Crabtree.

Report of the Convention Committee; W. C. Kunzmann, *Chairman*.

Reports of Secretary and Treasurer; J. H. Kurlander, *Secretary*, and H. T. Cowling, *Treasurer*.

Election of Officers.

Report of Progress Committee; G. E. Matthews, *Chairman*.

"European Film Markets Then and Now," by C. J. North and N. D. Golden, Department of Commerce, Washington, D. C.

Résumé of the Proceedings of the Dresden International Photographic Congress, by S. E. Sheppard, Eastman Kodak Co., Rochester, N. Y.

Report of the Historical Committee; C. L. Gregory, *Chairman*.

"Air Conditioning by the Silica Gel Method," by E. C. Holden, Silica Gel Corp., Baltimore, Md.

"Utilization of Desirable Seating Areas in Relation to Screen Shapes and Sizes and Theater Floor Inclinations," by Ben Schlanger, New York, N. Y.

"Design and Construction of Motion Picture Sets," by William Saulter, Paramount Publix Corp., Astoria, New York, N. Y.

1:00 P.M.—Luncheon.

2:00 P.M.—Papers (*Ballroom, New Ocean House*).

"Some Recent Educational Film Experiments," by Glenn Griswold, Fox Film Corp., New York, N. Y.

"The Optics of Projectors for 16-Mm. Film," by A. A. Cook, Bausch & Lomb Optical Co., Rochester, N. Y.

"Mechanical Advantages of the Optical Intermittent Projector," by J. L. Spence, Akeley Camera, Inc., New York, N. Y.

"A Sound Motion Picture Projector for 16-Mm. Film," by R. A. Miller and H. Pfannenstiehl, Bell Telephone Laboratories, New York, N. Y.

"Advantages of 16-Mm. Supersensitive Panchromatic Film in Making Medical Motion Pictures," by R. P. Schwartz, University of Rochester, Rochester, N. Y., and H. G. Tuttle, Eastman Kodak Co., Rochester, N. Y.

"Proposed Standards for 16-Mm. Sound on Film Dimensions," by R. P. May, RCA Victor Co., Camden, N. J.

Report of the Standards Committee; A. C. Hardy, *Chairman.*

"Proposed Changes in the Present Standard 35-Mm. Film Perforation," by A. S. Howell and J. A. Dubray, Bell and Howell Co., Chicago, Ill.

Report of the Color Committee; W. V. D. Kelly, *Chairman.*

8:00 P.M.—Lecture, illustrated with motion pictures, "Wonders of the Commonplace," by Norman McClintock, Koppers Research Corp., Ligonier, Pa. (*Ballroom, New Ocean House*).

TUESDAY, OCTOBER 6TH

8:30 A.M.—Registration.

9:30 A.M.—Papers (*Ballroom, New Ocean House*).

"Motion Pictures in Relief," by H. E. Ives, Bell Telephone Laboratories, New York, N. Y.

"A High Speed Stroboscope," by H. E. Edgerton, Massachusetts Institute of Technology, Cambridge, Mass.

Open Forum; "How Can the Motion Picture Engineer Be of Greater Service to the Producer."

Report of the Sound Committee; H. B. Santee, *Chairman.*

"Recent Improvements in Thermionic Devices," by M. J. Kelly, Bell Telephone Laboratories, New York, N. Y.

"Studio Organization," by Carl Dreher, RKO Studios, Hollywood, Calif.

Report of Committee on Revision of the By-Laws.

"A Method of Directly Measuring Distortion in Audio Frequency Systems," by W. M. Tuttle, General Radio Co., Cambridge, Mass.

"Size of Image as a Guide to Depth of Focus in Cinematography," by J. F. Westerberg, United Artists Studio, Hollywood, Calif.

1:00 P.M.—Luncheon.

2:00 P.M.—Inspection Trips to Massachusetts Institute of Technology or Harvard University.

8:00 P.M.—Exhibition of Recent Films of Interest (*Ballroom, New Ocean House*).

WEDNESDAY, OCTOBER 7TH

9:30 A.M.—Papers (*Ballroom, New Ocean House*).

"Development of the Light Valve," by T. E. Shea, Bell Telephone Laboratories, New York, N. Y.

"Vertical Sound Records; Recent Fundamental Advances in Mechanical Records on Wax," by H. A. Frederick, Bell Telephone Laboratories, New York, N. Y.

"Western Electric Noiseless Recording," by H. C. Silent, Electrical Research Products, Inc., Hollywood, Calif.

"A New Bell and Howell Printer," by J. A. Dubray, Bell and Howell Co., Chicago, Illinois.

Report of Studio Lighting Committee; M. W. Palmer, *Chairman*.

"The Bomb Microphone," by W. C. Miller, M-G-M Studios, Culver City, Calif.

"Studio Projection and Reproduction Practice," by J. O. Aalberg, RKO Studios, Hollywood, Calif.

"Sound Recording for Independent Productions," by L. E. Clark, Clarco, Inc., Hollywood, Calif.

1:00 P.M.—Luncheon.

2:00 P.M.—Papers (*Ballroom, New Ocean House*).

"Mechanism of Hypersensitization," by B. H. Carroll and D. Hubbard, Bureau of Standards, Washington, D. C.

"An Experimental Study of Several Methods of Representing Photographic Sensitivity," by R. Davis and G. K. Neeland, Bureau of Standards, Washington, D. C.

"The Variation in Emulsion Speed with the Distribution of Energy in Sources of Equal Visual Intensity," by R. Davis and G. K. Necland, Bureau of Standards, Washington, D. C.

"On the Assignment of Printing Exposure by Measurement of Negative Characteristics," by C. M. Tuttle, Eastman Kodak Co., Rochester, N. Y.

"The Reducing Action of Fixing Baths on the Silver Image," by J. I. Crabtree and H. D. Russell, Eastman Kodak Co., Rochester, N. Y.

"A Device for Printing Sound Films," by R. B. Wood and S. Watson, Jr., Rochester, N. Y.

"Gamma by Least Squares," by D. R. White, du Pont Film Mfg. Corp., Parlin, N. J.

"Speed in Camera Lenses and Emulsions," by Lewis Physioc, Hollywood, Calif.

"Depue Automatic Sound Printer," by O. B. Depue, Chicago, Ill.

"Special Process Technic," by Vern Walker, RKO Studios, Hollywood, Calif.

7:00 P.M.—Semi-Annual Banquet (*Dining Room, New Ocean House*).

THURSDAY, OCTOBER 8TH

9:30 A.M.—Papers (*Ballroom, New Ocean House*).

"Sound in the Los Angeles Theater, Los Angeles, Calif.," by D. M. Cole, Electrical Research Products, Inc., New York, N. Y.

"Thermionic Control of Theater Lighting," by B. S. Burke, Westinghouse Electric and Mfg. Co., Pittsburgh, Pa.

Report of the Projection Practice Committee; H. Rubin, *Chairman*.

Report of the Projection Theory Committee; W. B. Rayton, *Chairman*.

Report of the Projection Screens Committee, S. K. Wolf, *Chairman*.

"Sound Motion Picture Projector Equipment for the U. S. Navy," by S. W. Cochran, RCA Victor Co., Camden, N. J.

"Acoustical Treatment of Madison Square Garden," by S. K. Wolf, Electrical Research Products, Inc., New York, N. Y.

"Lighting the Modern Theater," by F. M. Falge, Beaded Screen Corp., New York, N. Y.

"The Screen—A Projectionist's Problem," by F. M. Falge, Beaded Screen Corp., New York, N. Y.

"Low Amperage Reflecting Arc Lamp for Portable Sound Equipment," by H. H. Strong, Strong Electric Co., Toledo, Ohio.

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Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

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Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N. Y., and should be accompanied by check or money-order.

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVII **NOVEMBER, 1931** **Number 5**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

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Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

PHOTOGRAPHIC SENSITOMETRY, PART II*

LOYD A. JONES**

Due to its length, Mr. Jones' paper on sensitometry which was presented in part on three consecutive days at the Spring, 1931, Meeting of the Society at Hollywood, Calif., will likewise be published in the JOURNAL *in three issues. The following is the second of the three installments. The paper deals in a tutorial manner with the general subject of sensitometry, its theory and practice. The third installment will be published in the January, 1932, issue of the* JOURNAL.

OUTLINE

I. Introduction.
- (*A*) Definition.
- (*B*) Scope of field.
- (*C*) Applications.
- (*D*) The characteristic D-log E curve.

II. Sensitometers.
- (*A*) Light sources.
  - (1) *Historical résumé.*
    - (*a*) Natural light (sunlight, skylight, *etc.*)
    - (*b*) Activated phosphorescent plate.
    - (*c*) British standard candle.
    - (*d*) The Hefner lamp.
    - (*e*) The Harcourt pentane standard.
    - (*f*) The acetylene flame.
    - (*g*) Electric incandescent lamps.
  - (2) *Spectral composition of radiation.*
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    - (*b*) The complete radiator.
    - (*c*) Color temperature of sources.
    - (*d*) Effect of color temperature on sensitivity values.
  - (3) *Modern standards of intensity and quality.*
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    - (*b*) Acetylene flame plus colored glass filter.
    - (*c*) Acetylene flame plus colored liquid filter.
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  - (4) *The international unit of photographic intensity.*
- (*B*) Exposure modulators.
  - (1) *Intensity scale instruments.*
    - (*a*) Step tablets (I variable by finite increments).

---

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Kodak Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

(*b*) Wedge tablets (*I* variable by infinitesimal increments).
(*c*) Luther's crossed wedge tablet.
(*d*) Tube sensitometer.
(*e*) Optical systems with step diaphragms.
(*f*) Optical systems with continuously variable diaphragms.

(2) *Time scale instruments.*
(*a*) Exposure intermittent.
Finite exposure steps (discontinuous gradations).
Infinitesimal exposure steps (continuous gradations).
(*b*) Exposure non-intermittent.
Finite exposure steps (discontinuous gradations).
Infinitesimal exposure steps (continuous gradations).

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(2) *For control of processing operations.*

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(4) *Intermediate density.*
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(3) *Progressive cut filters.*

III. DEVELOPMENT

The photographic material after exposure in the sensitometer must be developed, and since the amount of metallic silver produced by the development of a latent image formed by the action of a definite exposure depends upon so many factors involved in the development process it is evident that these various factors must be rigidly standardized if precise and reproducible sensitometric values are to be obtained. In choosing the development technic, the developing agent, and the constitution of the developing solution, *etc.*, due consideration must be given to the purpose for which the sensitometric work is being done and to the ultimate application of the results. For instance, the choice of a developer formula will depend upon whether it is desired to compare the inherent characteristics of various emulsions, to maintain in the manufacture of photographic materials a high uniformity of product over relatively long periods of time, to set up a nationally or internationally standardized sensitometric procedure so that the results obtained by different individuals engaged in the study either of theoretical or practical photographic problems may be intercompared, or to determine the characteristics of a particular material as used under certain specific practical conditions. For the purposes of standardization it may be quite desirable to adopt a developer formula (which on account of excellent reproducibility, low temperature coefficient, low sensitivity to changes in bromide concentration, *etc.*, meets the requirements of this problem) entirely unsuitable for many practical purposes. Likewise, the technic of development best adapted to the needs of standardizing and production control sensitometry may be quite unsuitable for control of practical processing operations. These various aspects will be considered in detail.

DEVELOPERS

It is well known that the various characteristics of any photographic material as determined sensitometrically by an analysis of the D-log E curve are, to a marked extent, influenced by the constitution of the developing solution. The effects of various reducing agents and of different proportions of the developer constituents (usually a reducing agent, a sulfite, an alkali, and a bromide) have been studied by many investigators among whom may be mentioned Hurter and Driffield,[43] Sheppard and Mees,[44] Kron,[45] Nietz,[46] Bloch,[47] Higson and Toy,[48] Mees and Piper,[49] A. and L. Lumière and

Seyewetz,[50] and many others. It has been shown that variations in the constitution of the developing solution may profoundly modify the rate at which development proceeds and the shape and position of the characteristic curve, thus affecting values of contrast (gamma), latitude, maximum density (D_{max}), fog, speed, *etc.* The specific effects of changes in concentration of various developer components have been summarized by Clark[51] who also gives a comprehensive bibliography of the subject. A careful study of his paper is recommended to those particularly interested in this subject.

Standard Developers.—Driffield[52] in a paper summarizing the results of the photochemical investigations made by himself and his collaborator, Dr. Hurter, writes as follows relative to the question of a standard developer: "As the result of our earlier investigations we decided in favor of ferrous oxalate as our standard developer, and an excellent standard it is from many points of view. It has, however, never been a popular developer and it has the drawback of being considerably less energetic than alkaline pyrogallol. After further investigation, therefore, we decided to employ a pyro-soda developer as our standard, satisfying ourselves that it possessed the requisite qualifications." The formula for the standard ferrous oxalate used by Hurter and Driffield is as follows:

A		*C*	
	Parts		*Parts*
Potassium oxalate	1	Potassium bromide	1
Water	4	Water	100
B		For use take:	
Ferrous sulfate	1	*A*	100
Citric acid	0.01	*B*	25
Water	3	*C*	10

Development to be conducted at a temperature of 65°F.

Mees and Sheppard (*loc. cit.*) also used a ferrous oxalate developer and considered it as a possible standard for sensitometric measurements but discarded it later as quite unsuitable. While its constituents are all inorganic compounds easily procurable in a high state of purity and susceptible of precise analysis by relatively simple chemical methods, its low reducing power and its unadaptability to practical use make it quite useless either for standardization or production control sensitometry. The standard pyrogallol formula recommended by Hurter and Driffield and adopted by them in 1898 is made up as follows:

	Parts
Pyrogallol	8
Sodium carbonate (recrystallized)	40
Sodium sulfite	40
Water to make	1000

It should be noted that the formula contains no bromide. Relative to this Driffield[53] says, "This omission is of the utmost importance, and must be insisted upon, at any rate, when determining the speed of a plate. While the pyrogallol and the alkali are essential elements of the developer, a bromide is altogether unessential."

For many years a pyro developer of some type was used very extensively in practice and while no official standard was ever adopted for sensitometry a pyro formula was used almost exclusively in production control, research, and practical sensitometry. While it is true, as stated by Hurter and Driffield, that bromide is an undesirable constituent of a developer since it causes variations in the value of inertia thus making speed values dependent upon the time of development, nevertheless the presence of a small amount of bromide is desirable from the practical point of view in order to prevent the excessive increase in fog when development time is much prolonged. The following formula has been used for many years and found very satisfactory for most sensitometric work.

Solution *A*	Sodium sulfite	876 g.
	Potassium metabisulfite	175 g.
	Pyrogallol	200 g.
	Water	10,000 cc.
Solution *B*	Sodium carbonate	750 g.
	Potassium bromide	10 g.
	Water	10,000 cc.

For use, take equal parts of *A* and *B*.

It may be said, therefore, that from the time Hurter and Driffield proposed the standard pyro formula down to the present the effective standard developer for sensitometric purposes has been of the pyrosoda type.

As long as the pyro developer was used so extensively in practical photographic work there were but few objections to its use in sensitometry. There is, however, one very serious objection, this being the staining effect which a pyro developer, especially one in which the concentration of sulfite is relatively low, has upon

the developed image. Some of the reaction products produced when the silver halide is converted into metallic silver by a pyro-soda developer are strongly colored and are absorbed to a certain extent by the gelatin immediately surrounding the developed grain. As a result the developed image has a yellowish color and the amount of this color is practically proportional to the mass of silver produced. This yellowish stain, which strongly absorbs the shorter wavelengths of the visible spectrum and the near ultra-violet (the blue, violet, and ultra-violet) has relatively little effect upon the density of the deposit as measured visually. Since, however, most materials upon which prints are made are sensitive chiefly to the blue, violet, and ultra-violet spectral region, the pyro stain has a very pronounced absorption for the light to which these materials are sensitive and therefore the *effective printing density* values are not in agreement with those measured visually. As a result a negative developed in a staining pyro developer has appreciably greater printing contrast than is indicated by a visual judgment or by measurements based upon visual density values. If it is desired to apply sensitometric measurements obtained with a pyro developer to practical printing problems, it is necessary, therefore, to make a correction for this effect.

During recent years this developer has been used less and less in practical work, not at all in motion picture processing, and to a negligible extent in the development of amateur negatives. It appears, therefore, to have ceased to meet the needs for standardized sensitometry. The question of an international standard developer for sensitometry was discussed at the Sixth International Congress of Photography.[54] The pyro standard was considered and rejected. The proposal of a metol-hydroquinone formula made by Odencrants also was objected to largely on the ground that it seemed undesirable to adopt a formula having two reducing agents. Sheppard proposed a *p*-aminophenol formula which met with considerable favor. In a paper by Sheppard and Trivelli[55] read at the Seventh International Congress of Photography the characteristics of this reducing agent and its adaptability for use in a standard formula were discussed, the following formula being recommended:

p-Aminophenol hydrochloride	7.25 g.
Sodium sulfite (anhydrous)	50.00 g.
Sodium carbonate (anhydrous)	50.00 g.
Water to make	1000.00 cc.

It should be noted that this formula contains no bromide and therefore, unless there should be free bromide present in the photographic material itself, there should be no regression of the inertia with increase in time of development and speed should be independent of development time. Moreover, this developer is relatively insensitive to the presence of bromide and hence even if there be free bromide in the photographic material, the effect upon value of inertia should be relatively small. In Table VI are given the speed

TABLE VI

Relative Speed Values Obtained with Proposed Standard Developer Formula

Low Speed Material	
p-Aminophenol	21.4
Pyrogallol	25.1
Elon-hydroquinone	19.9
Medium Speed Material	
p-Aminophenol	63.2
Pyrogallol	60.1
Elon-hydroquinone	65.2

values obtained with this standard developer as compared with those obtained with pyrogallol and with a metol-hydroquinone formula for two widely different types of photographic materials. It will be noted that in both cases the speed value for the proposed standard lies between those given by the other two reducing agents. The formula also shows excellent behavior from the standpoint of fog characteristics. This is illustrated in Fig. 24 and Fig. 25 which show the rate of growth of contrast (γ) and the rate of growth of fog as a function of development time, Fig. 24 showing these functions for the *p*-aminophenol formula and Fig. 25 for pyrogallol. This developer gives a gray (non-selectively absorbing) deposit, therefore readings of density made visually correspond with the effective photographic density values. In view of the excellent performance of this developer it seems probable that it will be adopted by the next International Congress of Photography as a standard developer for sensitometry.

Developers for Practical Work.—If the sensitometric work is being done for application directly to the control of practical processing operations, it is obvious of course that the developing solution employed should be identical in composition with that which is being used in the processing operations. In general, it may be considered

that the best developer to use for any particular material is that recommended by the manufacturer of the material in question. Furthermore, for processing control it should be remembered that it is not always sufficient to use a developer made up according to the formula adopted for practical work without taking steps to insure that this developer is *effectively* the same in its action upon the photographic material as that actually used. Practically all developing solutions begin to change their effective composition as soon as

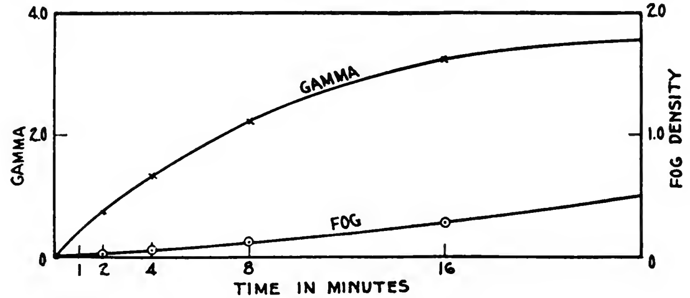

FIG. 24. Time-gamma and time-fog curves for the proposed standard *p*-aminophenol developer formula.

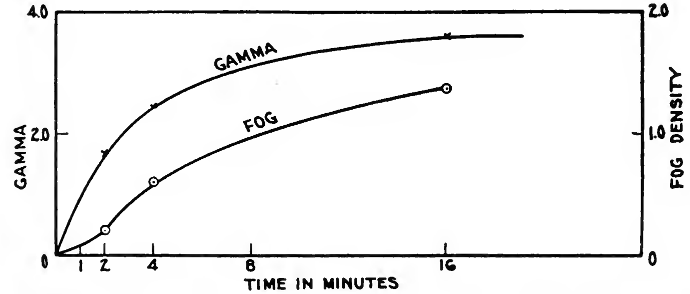

FIG. 25. Time-gamma and time-fog curves for a typical pyrogallol developer.

exposed materials are developed therein. A tank of developer in which a relatively large amount of photographic material has been developed suffers sufficient change so that its action is appreciably different than when the developer is freshly compounded. The best way, therefore, to insure that the sensitometric results shall be a precise index of the action of the developer on the exposed material is to actually develop the sensitometric strip along with the material being processed, attaching the sensitometric strip in some way so

as to insure that it is developed under the identical conditions to which the material to be controlled is being subjected.

TEMPERATURE CONTROL

The conversion of the exposed silver halide into metallic silver is a chemical reaction and the rate at which this reaction proceeds depends to some extent upon temperature. It might be expected that the only effect of variation in temperature would be to change the rate of development, an increase of temperature causing the reaction to proceed at an accelerated rate and *vice versa.* There appears, however, to be other related effects such, for instance, as that observed by Bloch[56] who found that a change in the temperature of development produces a shift in the value of gamma (for a fixed time of development) and also a change in the value of speed as based upon inertia. The effect of temperature is usually denoted by the *temperature coefficient* which is defined as the ratio of the velocity constants of development for a 10°C. temperature difference. This temperature coefficient depends upon the reducing agent and the constitution of the developing solution and is also dependent to some extent upon the photographic material. Values of temperature coefficient can be defined therefore only under restricted conditions. In Table VII are shown some values of the temperature coefficient

TABLE VII

Temperature Coefficient for Various Developers

Developer	Coefficient
Pyro-soda (H. & D.), without bromide	1.48
Pyro-soda, with bromide (Watkins)	1.9
Rodinal	1.9
Metol-quinol	1.9
Amidol	2.06
Quinol	2.25
Glycin	2.3
p-Aminophenol	2.4

for various developers. These should be taken as only illustrative of the magnitude of the variation to be expected since they depend to some extent upon the constitution of the developing solution and upon the photographic material. It will be noted that the pyro-soda standard formula as recommended by Hurter and Driffield shows a very low temperature coefficient, while the *p*-aminophenol has a

coefficient which is very high. This might be taken as an argument against the use of the latter developer as a standard for sensitometry. It is relatively easy, however, to control the temperature at which the development is carried out and hence this factor is not of great importance in deciding upon the adaptability of a developer for sensitometric purposes. It is quite easy to maintain the temperatures of the developing bath in which sensitometric strips are developed to within $\pm 0.1°C$. by the use of thermostatic control. This variation is insufficient to cause any serious error due to any temperature coefficient effect.

DEVELOPMENT TECHNIC

During the development process which involves the conversion of silver halide to metallic silver, soluble bromides and other reaction products are formed. The amount of bromides produced is proportional to the amount of silver reduced from silver halide and hence is the greatest in those portions of the sensitometric strip corresponding to high exposures. This bromide exerts a restraining action upon the development process, the resultant restraining action consequently being greatest in the regions of high density. If the process is carried out in a developer which is not stirred, the concentration of soluble bromides and of other reaction products tends to increase most in regions of high density from which it slowly diffuses out to the surface of the gelatin and, since it has a different density than the developing solution, it tends to form convection currents along the surface of the exposed material and thus locally alter the constitution of the developing solution. It is obvious, therefore, that unless efficient agitation of the developer is employed, the development may be uneven. As a matter of fact, it is extremely difficult to develop a photographic material in such a way that every point on its surface is subjected to a uniform action of the developer. This irregularity in the action of the developer over the surface of the exposed sensitometric strip is probably the most fruitful source of trouble in obtaining uniform and repeatable results in the sensitometry of photographic materials. The irregular markings produced by development under conditions of insufficient agitation have been studied in detail by Callier.[57]

It is essential in the development of the sensitometric exposure to secure a rapid distribution of the reaction products throughout the entire volume of the developer and this should be done immediately

after they diffuse out from the surface of the film. Some method of effectively and quickly producing this mixture is therefore necessary.

There are two general methods of development, one in which the photographic material is held in a vertical position in a tank or tube containing the developer, and the other in which it is held in a horizontal position such as in a tray or shallow dish. If the exposed material is suspended vertically it may be rotated rapidly about a vertical axis, thus causing a relatively rapid flow of developer laterally across the surface of the material. Since, however, density increases progressively from one end of the strip to the other, there is a likelihood that there will be a vertical gradient of reaction products unless, in addition to the rotation of the strip, some means is provided for additional stirring of the developing solution in a vertical direction. In fact, experience has shown that the mere rotation of an exposed sensitometric strip is not sufficient to give satisfactory uniform development. Strips of exposed material hung in a vertical position in the developer show very definitely the presence of convection currents arising from reaction products of a density differing from that of the developing solution itself. This has been studied in detail by Bullock[58] who has shown that in the case of vertical development without agitation a downward current prevails and therefore the rate at which development proceeds is greater at the top than at the bottom of the negative. The influence of the rate of flow of a developer across the surface of an exposed material has been studied quantitatively by Sheppard and Elliott,[59] who mounted the exposed sensitometric strips (film) on the outer surface of a cylinder which can be rotated at various velocities in the tank of developer.

Mechanical stirring of the developer in which the exposed strips may be supported on suitable holders is frequently employed, but great care must be taken in planning development tanks of this type to insure that the strips in all parts of the tank receive equally rapid circulation of the developer to make certain the elimination of variable rates of circulation over different areas of the individual strips. Dobson and Harrison[60] have devised a means whereby an extremely high velocity of developer at the plate surface may be obtained with the plate mounted in a vertical position in the tank. This involves the use of a plunger which moves up and down in the tank allowing a very narrow clearance between one face of the plunger and the photographic plate. Many different forms of developing machines for

the processing of sensitometric exposures have been devised, among which may be mentioned that of Sheppard and Crouch[61] in which provision is made so that strips are introduced into the developer automatically at predetermined time intervals.

For most purposes of sensitometry it is probable that the most convenient method of developing strips is to place them in a horizontal position in a tray or flat dish. The tray should, of course, be water jacketed and the temperature of the jacketing water be controlled thermostatically to within the required limits. A rather large volume of solution should be used so that the reaction products as they are formed may be greatly diluted and hence change very little the constitution of the developing solution. Agitation under such conditions may be obtained in several ways. Mechanical rocking has not been found very successful since the regularity of such rockers almost invariably tends to produce standing waves resulting in areas of no circulation. Rocking the tray irregularly and rather vigorously by hand has been found in general very satisfactory. Clark (*loc. cit.*) has proposed that in horizontal development, agitation be produced by stroking the surface of the material with a soft camel's hair brush. This can be done without injury to the surface of the plate and there is no doubt that extremely efficient removal of the surface film containing the reaction products is obtained. Under these conditions of rather vigorous brushing, the rate of development is appreciably higher than in case of the hand rocked tray method. Experience indicates that this method probably gives the best possible uniformity of development over the surface of the exposed strip. It is doubtful, however, whether the reproducibility of this method is as great as could be desired. For instance, different individuals in applying the brush development method obtain definitely variable rates of development. It appears that no two individuals exert just the same pressure on the brush, nor do they operate the brush at equal velocities. It seems doubtful, therefore, whether, from the standpoint of reproducibility, it is as good as the hand rocked tray method which, from rather exhaustive tests, indicates that various individuals obtain very reproducible development rates. On the other hand, if uniformity of development over the surface is of prime importance, it is probable that the brush method is the best that has thus far been proposed.

Considering again the desirable practice where sensitometry is being done solely for control of processing operations, it is evident

that the sensitometric control strips must be given exactly the same agitation treatment as that accorded to the materials being controlled. For instance, sensitometry which is designed to determine the contrast to which motion picture film is developed in some particular manner, as on a machine or in tanks, must provide for the development of the exposed sensitometer strips under conditions which simulate precisely those existing in practice. It is possible to do this without actually associating the strips with the materials being processed, but it is probable that the best and most satisfactory results will be obtained by the attachment of the strips to the material as it goes through the processing operation.

IV. THE MEASUREMENT OF DENSITY

Having now exposed the photographic material being subjected to sensitometric investigation to an appropriate series of exposures (this implies a precise knowledge of the t and I factors of exposure and also of the spectral composition of the radiation) and subjected the exposed material to uniform and reproducible development, it remains to evaluate in some manner the magnitude of the response (developed image) obtained. As mentioned previously, this evaluation may be made by simple visual inspection which in general yields only information as to the exposure required to produce (for the particular development conditions used and for the mode of inspection adopted) a visually just perceptible silver deposit. Much more information relative to the characteristics of the material can be obtained, however, by *measuring quantitatively* the magnitude of the silver deposit corresponding to the various exposures. This is usually done by an optical method which determines the light absorbing or transmitting power of the silver deposits.

OPTICAL CHARACTERISTICS OF THE IMAGE

Hurter and Driffield (*loc. cit.*) defined the light absorbing power of the developed image in terms of *density* (D) as follows:

Let F_0 = luminous flux incident on the silver deposit
F_1 = luminous flux transmitted by the silver deposit
T = transmission factor
O = opacity
D = density

$$T = F_1/F_0$$
$$1/T = O = F_0/F_1$$

They found that density as specified above is directly proportional to the mass of silver per unit area of the desposit. Therefore,

$$D = p.m$$

where m is the mass of metallic silver per unit area, and p is a constant (called the photometric constant). It has since been shown by Meidinger[62] that the value of p is not constant under all conditions. More recently Sheppard and Ballard[63] have confirmed this result and, employing a highly refined method of measuring m, have shown, for some photographic materials at least, that p increases with the time of development and that it tends to decrease with increasing exposures, as a result probably of the decrease of mean grain size resulting from high exposure values. They found, moreover, that the value of p for a silver deposit resulting from the development of a silver halide exposed to light is very different from that for a deposit resulting from prolonged development, that is, development fog.

Scatter of the Transmitted Light.—An examination of the distribution of the light transmitted by a silver deposit shows that a part of it in passing through is deviated from the direction of incidence or, as more commonly stated, it is partially *scattered* or *diffused*. This condition, in generalized form, is illustrated in Fig. 26 in which

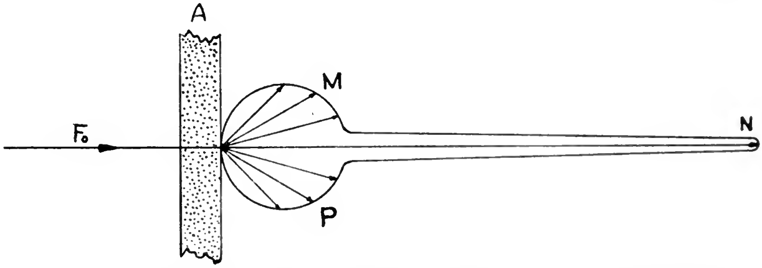

FIG. 26. Diagram illustrating distribution of radiant flux transmitted by a developed silver image.

the line F_0 represents a narrow pencil of parallel (collimated) light rays incident normally upon the granular silver deposit A. The polar diagram at the right shows the distribution of the transmitted light. The lengths of the vector lines shown are proportional to the luminous flux, per element of solid angle, transmitted in the various directions as indicated. The envelop, MNP, of these vectors becomes the distributional diagram which, as shown in Fig. 26, is,

of course, a section in the plane of the incident ray, F_0, the complete distributional form being given by the three-dimensional surface formed by the revolution of the plane figure, *MNP*, about the axis coinciding with the incident ray, F_0. The thickness of the silver deposit indicated at *A* is, of course, greatly magnified in the figure and is actually relatively thin as compared with the dimensions of the distributional diagram. In fact, the scattering material may be considered as confined to an extremely thin layer. Scatter of the light begins as soon as the incident ray enters the first surface or the gelatin layer containing silver grains, this surface, in fact, being very close to the second surface of the scattering layer as shown at *A*. Now it is evident that the value of F_1, the transmitted flux, will depend upon the manner in which the measure of its magnitude is made and hence various values of F_1, and consequently of *D*, may be obtained for the same silver deposit. It is necessary, therefore, to define specifically the mode of measurement and to attach definite significance to the different values of density (*D*) thus obtained.

Diffuse Density.—Definite modes of measuring the magnitude of the transmitted flux, F_1, are illustrated schematically in Fig. 27. The silver deposit is in this case represented by the line, *D*, and actually is relatively thin. Again the silver deposit is illuminated by a narrow pencil of parallel light indicated by F_0 which is normal to the surface of the layer containing the silver deposit. The diagram at the top of Fig. 27, designated as *A*, shows one characteristic method whereby the transmitted flux may be measured. An integrating sphere, *S*, which consists of a hollow sphere, the inner surface of which is covered with a diffusely reflecting layer of relatively high reflection coefficient, is placed in contact with the silver deposit, *D*, in such a manner that the gelatin layer becomes practically a part of the inner surface of the sphere. The aperture, *C*, is relatively small as compared with the entire area of the sphere surface. This aperture, therefore, subtends at the point of incidence of the ray, F_0, a solid angle equivalent to a plane angle of 180 degrees. All of the light which is transmitted by the silver deposit whether it be scattered or transmitted without deviation is collected by the sphere and integrated. A small aperture, *O*, in the one wall of the sphere is provided so that the brightness of the interior sphere surface can be observed and measured. The theory of the integrating sphere as used in photometry was first treated by Ulbricht[64] in 1900, and since that time has been employed very extensively for the measurement of mean spheri-

cal candle power and of the reflection and transmission characteristics of diffusing and semidiffusing materials. The literature of the subject is very voluminous and for a comprehensive summary the reader is referred to a treatment by Walsh.[65] The value of density computed from the transmission measurement made in this manner is referred to as *diffuse density.* It should be observed that this value is based upon the measurement of the *total* transmission of the silver

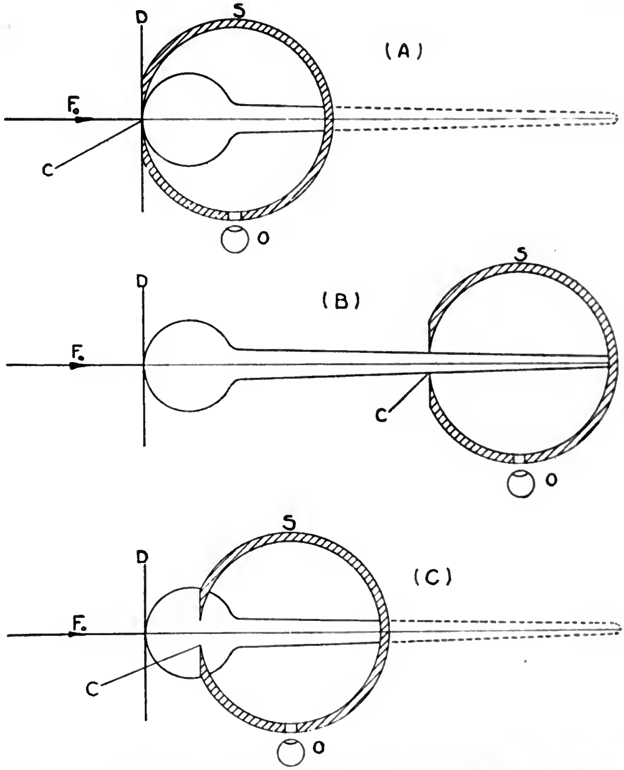

FIG. 27. Diagrams illustrating the significance of (*A*) diffuse density, (*B*) specular density, and (*C*) intermediate density.

deposit; that is, all of the light which is transmitted, whether it be *diffused* or *specular* (undeviated), is collected and integrated. The value of *diffuse density,* therefore, does not represent the diffused transmission of the diffusing layer in question.

Specular Density.—Now, if the condition of measurement be changed to that shown in Fig. 27 at *B*, an entirely different condition

obtains. In this case the integrating sphere is moved away from the silver deposit so that the opening, C, subtends a *very small* angle at the point where the incident ray, F_0, intersects the plane, D. As shown in the figure the desired condition is not obtained since it is impossible, within the boundaries of the figure, to show a sufficient separation between the integrating sphere and the plane, D. In practice where it is desired to measure the purely specular transmission a much greater relative separation is used so that the angle subtended by the aperture, C, is very small, in fact, approaching zero as closely as is practicable. Under these conditions only that light transmitted without deviation by its passage through the silver deposit enters the sphere. If now, a second measurement of the brightness of the sphere wall is made a value of the transmitted flux will be obtained which obviously will be less than that in the case shown at A. Density based upon this value of transmission will obviously be greater and hence for diffusing media, such as a developed silver image, specular density is always greater than diffuse density. The magnitude of the difference depends upon the characteristics (*i. e.*, grain size, grain shape, grain size-frequency distribution, thickness of layer, *etc.*) of the particular material.

Intermediate Density.—Now, it is evident that an infinite number of values for the transmitted flux may be obtained by placing the integrating sphere in intermediate positions, one of which is shown at C in Fig. 27. In this case the aperture of the sphere subtends, at the point where the incident ray, F_0, intersects the plane, D, an angle less than 180 degrees but greater than that subtended by the same aperture when placed at a greater distance. In this case the value of transmitted flux obtained will be intermediate between those obtained under A and B. The value of density computed therefrom will also be intermediate between those measured under the two conditions previously mentioned. It is therefore possible in measuring the value of transmitted flux to obtain anything between two limits. It is obvious from the foregoing consideration of methods of measurement that it is essential to define specifically the mode by which the measurement of the transmitted flux is made.

Relation between Diffuse and Specular Values.—The relation between values of diffuse and specular density in the case of developed photographic images was first investigated by A. Callier.[66] He adopted a nomenclature in which $D \parallel$ is used to designate the value of specular density and $D \#$ to represent values of diffuse density.

The ratio of $D \parallel$ to $D \#$ he designated as Q and since that time this ratio usually has been referred to as Callier's Q factor. He found that

TABLE VIII

Ratio (Q) of Specular to Diffuse Density for Various Types of Photographic Materials

Material	Q Value
Lippman plates (grainless)	1.0
Very fine-grained transparency plates	1.2
Lantern plates	1.35–1.5
Medium speed plates	1.6
High speed plates	1.7
Highest speed plates intensified with mercury	1.9

Q was constant for all values of density and hence a single number represented for a given material the relation between specular and diffuse density values. In Table VIII are shown some typical values of the Q factor for various photographic materials.

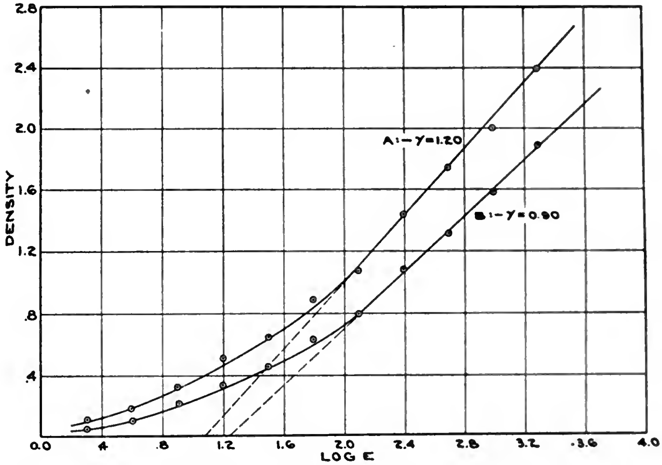

FIG. 28. Characteristic D-log E curves plotted from specular (curve A) and diffuse (curve B) values of density.

This subject of the relation between diffuse and specular density was later investigated by Renwick and Bloch[67] who found that Q was not constant for all values of density but could be expressed as a logarithmic function of density. Still later Tuttle[68] studied the subject experimentally and verified the findings of Renwick and Bloch showing definitely that Q is not constant. In Fig. 28 are shown two characteristic curves plotted from the same sensitometric strip, curve A being plotted from values of specular density, while B is

plotted using values of diffuse density. The actual density measurements are shown in Table IX in the last column of which are tabulated the values of Q, this being the ratio of specular to diffuse density. It will be seen from these values that Q decreases very markedly as density increases. The subject has been treated theoretically by Silberstein and Tuttle[69] who derived an equation of logarithmic form showing the relation between diffuse and specular density. The validity of this formula has been checked by actual measurements and the theoretical values computed therefrom agree excellently with experimental observations.

TABLE IX

Data Illustrating Dependence of Q upon Density

$D\#$	$D\|$	$D\| / d\#$
0.0641	0.108	1.68
0.110	0.180	1.64
0.223	0.332	1.49
0.355	0.509	1.41
0.460	0.650	1.41
0.550	0.770	1.40
0.640	0.891	1.39
0.790	1.07	1.36
1.08	1.44	1.37
1.31	1.75	1.34
1.58	2.00	1.25
1.89	2.40	1.27

Effective Density in Contact Printing.—From a consideration of the conditions which exist when a contact print is being made from a negative, it is evident that the sensitive surface of the printing material receives all of the light transmitted by the silver deposits in the negative whether this ray be scattered or transmitted without deviation. It is to be expected, therefore, that the effective value of density under these conditions is that already defined as diffuse density. Experimental data show that this assumption is correct or at least is subject to very slight errors. This has been investigated experimentally by Toy[70] who concludes that for all practical purposes the density values as measured under conditions specified as yielding diffuse density are entirely satisfactory for use in contact printing. Renwick,[71] however, found that the effective contact printing density has a value intermediate between that of diffuse and specular and concludes, furthermore, that the effective printing density for a

photographic negative depends to some extent upon the printing medium and consequently no fixed method of measuring this can be specified. It seems quite safe, however, to assume that for practical purposes values of diffuse density are entirely satisfactory for use as effective contact printing density values.

Effective Density for Projection.—A consideration of the geometric optics involved in a projection system will show at once that the effective value of density under these conditions is not the diffuse density. The image forming lens, for instance, must be placed at some appreciable distance from the silver image and hence cannot possibly collect all of the transmitted light. In most cases, moreover, the lens subtends a very appreciable solid angle as measured at the point where the optical axis intersects the plane of the photographic deposit. It is apparent, therefore, that the effective value cannot under these conditions be identical with the specular density value as previously defined which specified that the collecting system shall subtend a *very small* solid angle. In fact, it has been shown experimentally that the effective projection density of the silver deposit lies at some point intermediate between the diffuse and specular values. In general, however, it is much closer to the specular value and in some cases approaches the specular value very closely. It is impossible, therefore, to make any general statement as to the *effective projection density* of a developed photographic image. It can only be determined when all of the geometrical optical factors of the projection system are known and specified. If a very wide aperture lens is used, one subtending, let us say, an angle of 30 degrees at the point where the optical axis intersects the plane occupied by the photographic deposit, the effective projection density will be appreciably less than when a lens of very small aperture, for instance, one subtending an angle of 5 degrees, is employed. If it is important that the effective projection density values be known, it is highly desirable that they be measured in an optical system, the characteristics of which are identical with those in which the finished product is to be used.

Color Index.—All of the above statements relative to the effective printing and projection densities are based on the assumption that the silver deposits in question are spectrally non-selective absorbers. This non-selectivity must exist throughout the range of wavelengths to which the human eye is sensitive and also throughout the wavelength range to which the photographic material, in terms of which the effective printing density is to be evaluated, is sensitive. For all

practical purposes it may be considered that the eye is sensitive to wavelengths from 400 to 700 mμ. We may also consider that for the majority of practical purposes the long wavelength limit of photographic sensitivity is 700 mμ. The short wavelength limit of the sensitivity of photographic material is somewhat less determinate, extending well down into the far ultra-violet. The effective short wavelength limit, however, is determined, as a rule, not by the sensitivity of the photo halides themselves but by the absorption of other materials in the printing system. Except in rare cases glass forms some part of this printing system and the varieties of glass commonly used transmit very little radiation of wavelength shorter than 350 mμ. It may be considered for practical purposes, therefore, that the wavelength range, within which it has been assumed in the previous discussion of effective printing densities that non-selective absorption exists, extends from 350 to 700 mμ. It is of course obvious that in special cases where the sensitivity of the photographic material may extend to wavelengths greater than 700 mμ and where the optical system is of such character that wavelengths shorter than 350 mμ are transmitted, it may be necessary to extend in one or both directions the wavelength range mentioned above.

The assumed spectral non-selectivity of absorption for photographic deposits is in general justifiable for developers such as ferrous oxalate, metol, hydroquinone, *etc.* The assumption, however, is not always valid. For instance, previous mention has been made of the fact that photographic images obtained by the use of certain developers, notably those employing pyrogallol as a reducing agent, exhibit marked selective absorption. In the case of this developing agent some of the reaction products of development are colored materials and these are absorbed by the gelatin immediately surrounding the developed silver grains. The amount of these colored products produced and absorbed at any point in the developed silver image is very nearly proportional to the density of the silver image at the point in question. The magnitude of the resultant selective absorption is therefore directly proportional to the density of the silver image. In the case of pyrogallol these reaction products are blue absorbers. Hence they absorb the wavelengths of radiation to which photographic materials (especially positive materials) are in general most sensitive to a greater extent than those to which the eye is sensitive. The *effective printing density* of such a selectively absorbing image is therefore greater than is indicated by the visually measured density

value. Since the amount of selectively absorbing material associated with the developed silver image is directly proportional to the density of the silver image, the effective photographic printing density is greater than the visually measured density by the same proportionate amount for all values of density. It follows, therefore, that the *shape* of the characteristic density-log exposure curve, as plotted from the effective photographic densities, is the same as that plotted from the visually measured density values with the exception that all densities are increased just as they would have been by the use of a longer development time. The slope of the straight line portion of the curve plotted

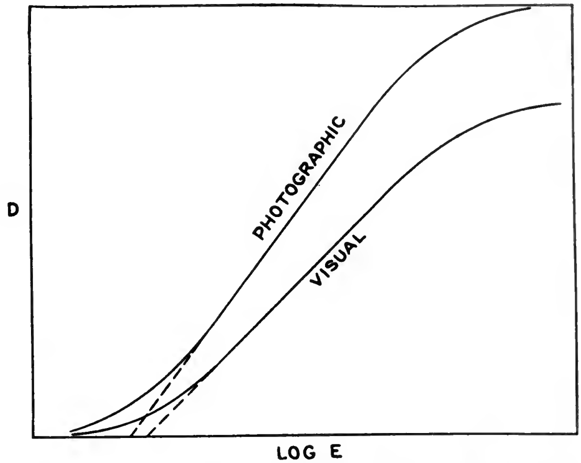

FIG. 29. Characteristic D-log E curves based upon values of visual and photographic diffuse density, the difference being due to the presence of selective absorption in the image.

from the effective photographic densities is therefore greater than that plotted from the visually measured values.

The ratio of the slope (γ) of the straight line portion of the characteristic curve, based upon the photographically measured density values, to that of the characteristic curve, based upon the visually measured values, has been defined by Jones and Wilsey[72] as the color coefficient (χ). While the value of the color coefficient depends chiefly upon the developer, it depends also to a certain extent upon the photographic material developed therein. Pyro developers made up with relatively high concentrations of sulfite give low color coefficients, while if the sulfite concentration be reduced to a very low level, the color coefficient may be very high. In Fig. 29 the character-

istic curves shown are those based upon the visually and photographically measured values of diffuse density, and apply to a sensitometric strip developed in a pyro solution of relatively low sulfite concentration. In Table X are shown values of color coefficient obtained

TABLE X

Values of Color Coefficient (χ) *for Various Sulfite Concentrations*

Sulfite	Color Coefficient
50	1.16
25	1.24
15	1.30
10	1.45
5	1.80
0	2.75

in a pyrogallol developer containing 50 grams pyrogallol per liter, 10 grams sodium carbonate, and various concentrations of sodium sulfite as shown by the values in the first column of the table.

FOG AND FOG CORRECTION

Source of Fog.—From the sensitometric standpoint any density which arises from sources other than exposure to light in the sensitometer is referred to as fog. Fog may be considered as falling into two categories: (*a*) inherent fog, and (*b*) development fog. The former may be subdivided into (i) fog arising from grains made developable by the chemical processes involved in the making of the emulsion, and (ii) fog from those made developable by exposure of the emulsion to light either during manufacture, inspection, packing, or during the handling of the material in the darkroom prior to or subsequent to its exposure in the sensitometer. Development fog as defined above may also arise from such various causes as the action of fogging agents or reaction products in the developer, aerial oxidation, *etc.* While from certain points of view the exact cause of fog is of great interest for the purpose of this discussion it seems unnecessary to consider it in further detail.

While Hurter and Driffield realized that in sensitometric work it was not entirely correct to assume that fog (and by this we mean the entire fog due to all causes) was uniformly distributed over all densities, but should be less over the higher densities, in their sensitometric work they nevertheless made a correction for fog by measuring the density of an unexposed area which had been subjected to the same

development treatment as the sensitometric strip to which the correction was to be applied and by subtracting this value from all of the measured densities.

In his experimental work, Nietz[73] has observed that the fog overlying the lower densities is appreciably higher than that overlying the higher densities. This was indicated by the fact that at longer times of development the growth of density with time appeared to be greater for the lower densities than for the higher. Furthermore, this effect was of much greater magnitude under conditions where fog tended to be great. It is obvious, therefore, that the subtraction of a uniform fog value from all densities may lead to very erroneous conclusions as to the sensitometric characteristics of a material.

Fog Correction Formulas.—Meidinger,[74] in studying this problem, proposed the following formula whereby each density could be corrected for fog more accurately than by the Hurter and Driffield method:

$$D_f = \frac{D_m - D}{D_m - F}$$

where D_f is the fog to be deducted, D_m the maximum developable density, D the observed density, and F the fog density on an unexposed area.

Wilsey[75] has proposed a modification of the Meidinger formula which gives theoretically a better approximation to the truth. That is

$$D_f = \frac{D_m - D_\infty}{D_m - F}$$

in which D_∞ is the limiting image density which can be obtained on extended development of the particular exposure under consideration.

If the value of F in the above equation be measured on an area remote from the exposed areas, a value somewhat too high will be obtained since this area is not subjected to the action of the reaction products of development which are inherently restrainers. A somewhat closer approximation can be obtained as suggested by Bloch who recommends that a small unexposed area be left in the middle of each sensitometer exposure so that the development conditions, from the standpoint of the presence of reaction products, will be somewhat closer to those conditions which exist in the development of the sensitometric images themselves. This question has been further studied by Trivelli, Wightman, and Sheppard,[76] and also by Prit-

chard[77] who developed experimental methods of correcting for fog by a study of the growth of fog at very extended development times. He concluded from his experimental observations that the Wilsey equation for fog correction gave satisfactory results provided the image is developed almost to gamma infinity before fog reaches a value of 0.5.

DENSITOMETERS

The instruments used for measuring the density of photographic deposits are essentially *photometers*, frequently of specialized forms called *densitometers* especially adapted to the particular problem. It may be interesting to consider briefly the evolution of these instruments, particularly as used for measuring the density of photographic deposits.

Bench Photometers.—It is probable that the first quantitative measurements of the transmission of developed silver images were made by Abney.[78] He used a photometer of the Rumford[79] type which is essentially a bench photometer in which the variation in the illumination on the photometric screen is obtained by changing the distance between the screen and a light source, the illumination being computed by means of the inverse square law.

Hurter and Driffield, in their classical investigations of the photographic processes, used a photometer of the Bunsen[80] type which is also a bench photometer involving the use of the inverse square law for the computation of illumination values. A lengthy and rather acrimonious controversy[81] was carried on by Hurter and Driffield and Abney regarding the relative merits of these two methods of measuring photographic densities, and as to the significance of the density values as measured by the two methods. While the Bunsen photometer was a marked improvement over preceding forms, it was soon replaced for high precision photometric work by a bench photometer using the now well-known Lummer-Brodhun photometer head.[82] This photometer head, especially in the form employing the contrast type of field, permits equality of brightness settings to be made with the maximum possible precision and is the type universally used in all modern high precision photometry. Wherever it is desired to make photographic density measurements on a bench photometer this photometer head should be employed.

Polarization Photometers.—A very convenient method of controlling the intensity of a beam of light is by means of polarization.

For instance, if a polarizing device, usually designated as a *polarizer*, is used for the production of a beam of plane polarized light, another device, the analyzer, of the same or similar type, may be placed in alignment with the polarizer, and by rotation of the analyzer the intensity of the light transmitted by the combination may be controlled. The intensity of the light transmitted by such a combination of polarizer and analyzer depends upon the angle between the polarization planes of the two elements, and this intensity may be computed precisely by the well-known laws of optics. This principle has been

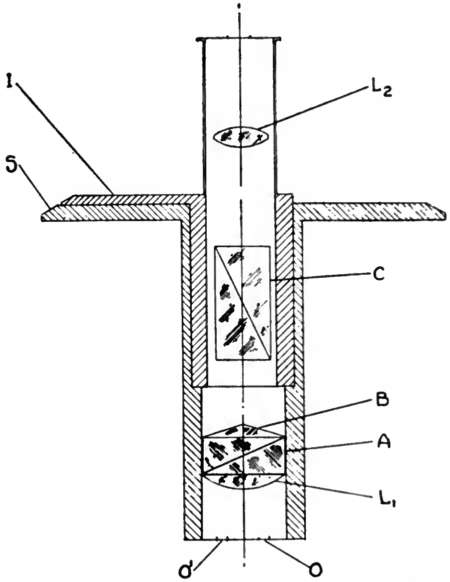

FIG. 30. Schematic diagram showing optical parts of Martens polarization photometer head.

used freqently in the design of photometers and is particularly applicable to the design of densitometers. One instrument of this type, known as the Martens polarization photometer[83] has been used very extensively in sensitometry for the measurement of density. The sensitivity of the instrument is excellent and since it is of so much importance in the densitometry of photographic plates it deserves a somewhat detailed description.

In Fig. 30 is shown a schematic diagram illustrating the arrangement of various parts. Two beams of light enter the instrument

through two circular apertures, O and O', each approximately 6 mm. in diameter. Both of these beams are polarized by means of the Wollaston prism, A, which splits the light into two components, one of which is polarized in a plane perpendicular to that of the plane of polarization of the other. On the upper face of the Wollaston prism is cemented a Fresnel biprism which forms the photometric field. The analyzing prism, C, is of the Nicol type. The lens, L_1, cemented to the lower face of the Wollaston prism is a field lens, while L_2 is the eyepiece lens. The analyzing prism, C, is supported so that it may be rotated about the optical axis of the instrument, its orientation being indicated by the index, I, reading on a scale, S, which remains in a fixed position relative to the Wollaston prism, A. The photometric field as seen by the eye placed at the exit pupil of the eyepiece is circular in shape, divided along a diameter by an image of the apex of the biprism, B. The field thus consists of two juxtaposed semicircular areas, the relative brightness of the two being controlled by a rotation of the analyzer, C. One-half of this photometric field is illuminated by light which enters the aperture O, while the other is illuminated by light which enters the aperture O'. If the intensities of the two beams entering the instrument are equal, the two halves of the photometric field will be of identical brightness when the index, I, reads at 45 degrees on the scale, S, or at a similar position in each of the other three quadrants of the graduated scale, S. If an absorbing material is placed over one of the apertures (either O or O'), the two parts of the field will no longer be of equal brightness, but by rotating the analyzer, C, the equality of brightness can be restored. The relative brightness of the two parts of the photometric field for any specified angular relationship between the position of the analyzer and the polarizer may be computed by means of the tangent square law. Hence for any setting which has been made to equalize the brightness of the two fields, after the insertion of the photographic density is one of the two beams, the magnitude of that density may be directly computed.

The instrument shown in Fig. 30 is usually referred to as the Martens polarization photometer head, and in order to construct a satisfactory instrument for the measurement of density this must be associated with certain elements suitable for illuminating the photographic density to be measured and for providing the comparison beam. One arrangement for the provision of satisfactory illumination is shown in Fig. 31 in which M represents a ground glass diffusing

surface illuminated to a relatively high level by some external light source placed to the left of *M* in the figure. The total reflecting prism *p* reflects light from *M* through one of the apertures in the nosepiece of the photometer head thus serving to provide the comparison beam which illuminates one-half the photometric field. A lens, *l*, mounted as shown just below the nosepiece of the photometer head, forms an image of *M* approximately in the plane occupied by the apex of the Fresnel biprism. A second total reflecting prism, *q*, reflects light from *M* through the other aperture of the nosepiece, thus illuminating

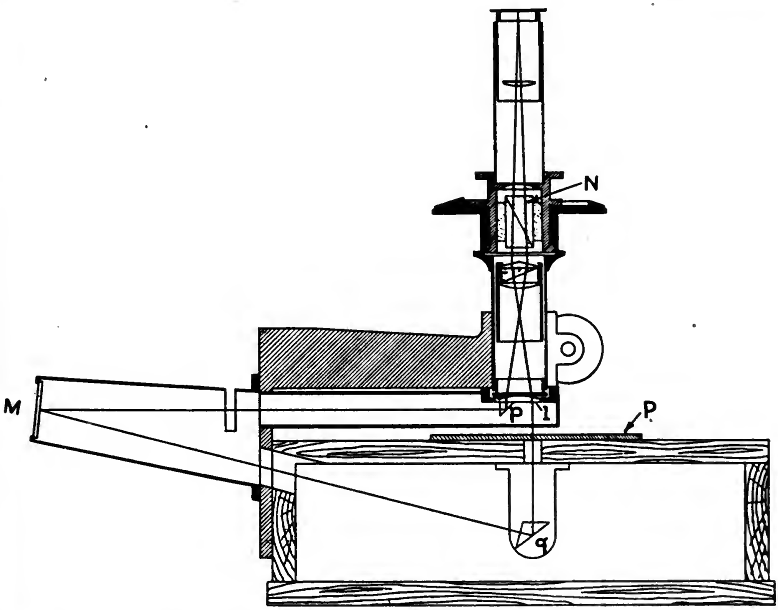

FIG. 31. Schematic diagram showing the arrangement of a split beam illuminator with Martens photometer head.

the other half of the photometer field. The photographic plate or film to be measured is placed in the position as indicated by *P*. In this arrangement of the Martens polarization photometer the illumination of the photographic deposit to be measured is by means of a semi-specular beam of light; hence the value of density read by the arrangement as shown in Fig. 31 approaches that of specular density for the deposit in question. By placing a small disk of white pot opal glass immediately below *P*, it is quite possible to obtain readings of diffuse density. In this case it will, of course, be necessary to balance

the illuminations by the insertion of a proper amount of absorbing material in the comparison beam reflected by the small prism, p. Under such conditions it is somewhat difficult to obtain sufficient illumination to read very high densities with precision. The ground glass, M, may, however, be removed, and, by using a light source of high intrinsic brilliancy and a properly designed optical system, a high concentration of light flux may be obtained on the opal glass directly underneath P and in this way more satisfactory results obtained in reading high values of diffuse density.

The split beam type of illuminator as illustrated in Fig. 31 is very convenient where it is necessary or desirable to read densities over a relatively large plate since, owing to the form of construction, it is possible to place a photographic image that is well inside the boundaries of the plate or film in position for measurement.

Another form of mounting for the Martens polarization head is illustrated in Fig. 32. This consists of an aluminum casting which forms an almost cubical box in which is placed a high wattage incandescent electric lamp. The top of this box is formed by a sheet of bakelite in the center of which is mounted a disk of white pot opal glass slightly larger in diameter than the nosepiece of the Martens polarization photometer head. The incandescent lamp is placed directly below this opal glass window in such a manner that the opal glass is uniformly illuminated to a relatively high level. The photometer head is mounted on the swinging arm shown so that in the reading position it is directly above and centered on the opal glass window. A metal slide is mounted transversely on the top of this lamp housing and in this slide operates a holder carrying the sensitometric strip to be measured. This is so arranged that the sensitometric densities pass under one of the apertures in the nosepiece of the photometer head, while the other aperture is covered by a portion of the photographic material which has received no exposure but which has received the same development as the sensitometric exposure. In this manner the fog is automatically subtracted in the act of reading the density. In other words, the density of a sensitometrically exposed area is read in terms of the density of an area of the photographic material which has received no exposure in the sensitometer but which has been subjected to development. It is of course possible, if desired, to arrange the holder and the sensitometric strip in such a manner that density is read over the edge of the sensitometric strip and in this manner values of sensitometric density

plus fog are obtained. The surface of the photographic emulsion during reading is in contact with the surface of the white pot opal glass. Hence density values obtained in this manner are those of diffuse density and consequently practically identical with the effective printing density of the deposit, provided, of course, the deposit has no selectively absorbing characteristics. This instrument, while very convenient for the reading of sensitometric strips in which the

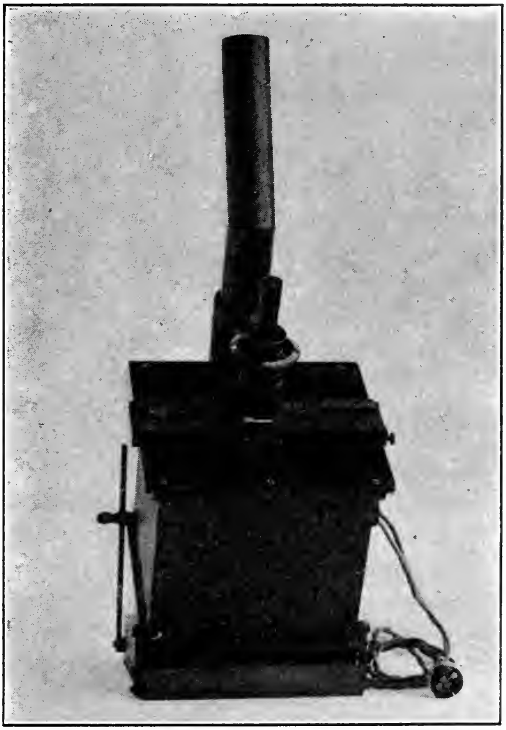

FIG. 32. Illuminator for use with Martens polarization photometer.

silver deposits lie relatively close to the edge, it is not at all adapted to the measurement of density on a large sheet of film or plate where these densities lie far from the edges.

Integrating Spheres.—In discussing the character of diffuse and specular density values mention has already been made of the use of an integrating sphere in the measurement of the total radiant flux

transmitted by the developed silver image. On the basis of this total transmission the value of density referred to as diffuse density may be computed according to the equation already given. It should be remembered that a density value measured in this manner is based upon a measurement of the total luminous flux which is transmitted through the deposit without deviation (that is, specular transmission) plus the luminous flux which, during passage through the silver image, is scattered or diffused. Some confusion might be avoided by reference to a density value determined in this manner as *total* density rather than *diffuse* density. In the case of a material producing complete diffusion of the transmitted flux the two values of course will be identical but in the case of a material which produces only partial diffusion of the transmitted flux, there is a distinct difference between the two values and it should be borne in mind that the effective contact printing density (in the absence of specular selectivity of absorption) must be based upon the value of total transmission.

An integrating sphere employed in the manner indicated in Fig. 27 may be used to advantage for measurement of this total transmission (or total density) value. The method has not been applied very extensively in practice, probably owing to the difficulty of obtaining sufficient illumination of the interior sphere walls in the case of high photographic densities. In order for an integrating sphere to function satisfactorily in the measurement of total transmission it is necessary that the area of the aperture over which the photographic density is placed shall be small relative to the total area of the interior sphere walls. It is evident, therefore, that a relatively high flux density must enter the small aperture in order to obtain a sphere wall brightness sufficiently high for precise work. When it is realized further that it is frequently desirable in the densitometry of photographic deposits to measure up to densities of 4 (corresponding to a transmission of 0.01 per cent) the difficulty of obtaining sufficient illumination of the sphere wall may be realized.

Instruments for the measurement of density by means of the integrating sphere principle have, however, been devised and used to some extent. The general principles involved have been discussed at some length by Karrer,[84] who has suggested several possible arrangements of such an instrument including one or two integrating spheres, the light source to supply the illumination, and a comparison photometer (such as the Martens polarization head) for making the neces-

sary brightness measurements of the sphere walls. Taylor[85] has also designed and described instruments of this type.

An instrument for measuring simultaneously both diffuse and specular densities has been devised by Bull and Cartwright.[86] The arrangement of parts is shown schematically in Fig. 33. In this instrument two integrating spheres, A and B, are used, placed as shown. The light source used is a three-electrode carbon arc shown diagrammatically at the extreme left of the figure. In front of this is placed the screen, S, having a re-entrant window so that only the crater of the positive carbon serves as an effective light source.

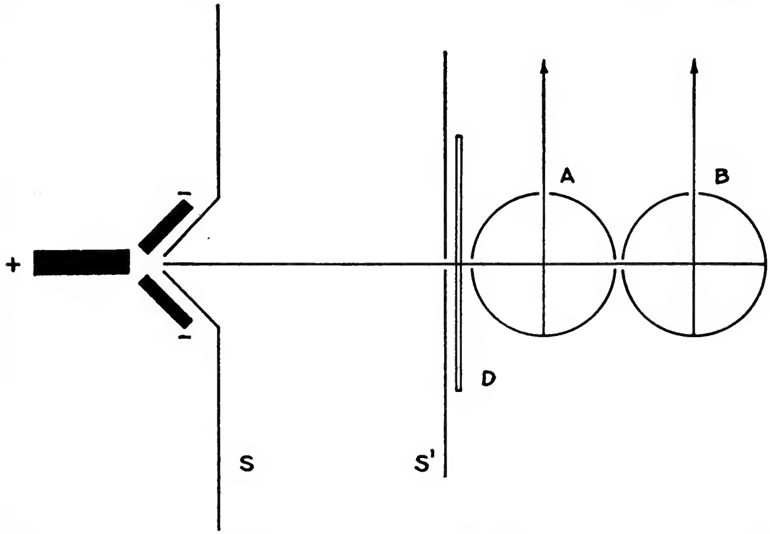

FIG. 33. Diagram illustrating use of integrating spheres for the separation of the diffuse and specular components of the transmitted radiation.

A second screen, S_1, placed at some distance from the screen, S, is pierced by a small aperture lying on the optical axis of the system. In this way a fairly well-collimated beam of light is obtained for the illumination of the photographic density which is placed at D close to the small hole in the wall of the sphere, A. The light which is specularly transmitted by the silver deposit, D, passes along the optical axis of the instrument through small apertures in the sphere walls and into the sphere, B. The brightness of the interior wall of sphere B is therefore proportional to the specular transmission of the deposit in question. The light which is scattered by the silver deposit, D,

illuminates the interior of sphere A and the brightness of the interior wall of sphere A is proportional to the diffuse transmission of the silver deposit, D. By means of a suitable photometric system the brightness of both sphere walls may be measured and values obtained simultaneously of both specular and diffuse density. It should be borne in mind that the value of density based upon the brightness of sphere wall A is not that of total density and hence is not the effective contact printing density usually referred to by the term "diffuse density." The instrument as designed by Bull and Cartwright serves to separate the diffuse and specular components of the transmitted flux and when properly used affords a means of evaluating the magnitude of the specularly transmitted flux, the diffusely transmitted flux, and hence, also, the total transmitted flux.

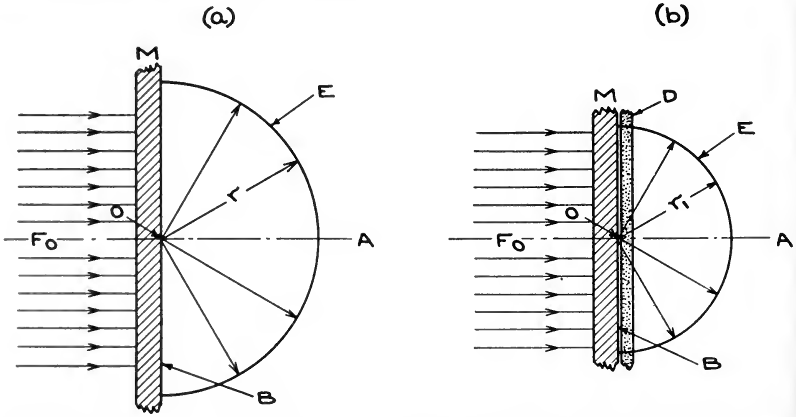

FIG. 34. Diagram illustrating the use of a completely diffusing material for the measurement of diffuse (total) density.

Completely Diffused Illumination.—In the earlier phases of the evolution of sensitometry the particular value of density usually desired was one which would be directly applicable to contact printing problems. It was necessary, therefore, to measure the total transmitted radiant flux. For this purpose it became almost the universal custom to place the silver deposit in question in contact with an illuminated diffusing material. The principle involved is illustrated in Fig 34. M represents a cross section through a material which produces complete diffusion or scatter of the transmitted light. This material is illuminated from the left by the radiant flux, F_0, indicated by the parallel lines. If the surface of M is observed from the right-hand

side its brightness will be independent of the angle of observation. This condition is illustrated by the polar curve, E, which is a semicircle drawn with radius r about the point, O, at which the optical axis, F_0A, intersects the surface, B. The length of the radius, r, is directly proportional to the brightness of the surface, B, and, as stated above, is independent of the angle of observation. This condition exists only when the radiant flux transmitted through the material, M, is completely diffused, and is difficult to obtain but may be approached with sufficient closeness for all practical purposes by using such materials as white pot opal glass, the surface (B) of which has been sand blasted or ground. If a semidiffusing medium, such as a developed photographic image, is placed in contact with the surface, B, of the diffusing material, M, as indicated in Fig. 34(b), it is evident, since the transmitted flux is already completely diffused, that the presence of this semidiffusing image cannot produce any further diffusion of the flux transmitted by it. The brightness of the surface, M, as observed through the deposit, D, will continue to be of equal magnitude regardless of the direction from which it is viewed. The distribution of the flux transmitted by D will again be shown by the polar curve, E, which is a semicircle drawn about the point, O. The radius, r_1, used in constructing this new polar curve E will be less than the radius, r, used in constructing the polar curve in Fig. 34(a). Assuming that F_0 is the same in the two cases illustrated in Fig. 34, the transmission of the semidiffusing deposit, D, will be given directly by the ratio r_1/r. The brightness of the surface, M, in the two cases is, however, directly proportional to the magnitude of the radii, r and r_1. In order to make a measurement of transmission by this method, therefore, it is necessary only to determine the brightness of the surface, B, without the silver deposit in position, and a second measurement of brightness of the same surface with the silver deposit in position as shown in Fig. 34(b). The ratio of these two brightness values gives the transmission from which the desired density value may be computed. It should be remembered that this method gives values of density which are based upon the total (specular plus diffused) transmitted flux.

It is probable that the term "diffuse density" was used originally to describe a measurement of density made in this manner, that is, by placing the silver deposit in question in completely diffused illumination. There are certain relatively small errors introduced by this method of measurement due to interreflections between the

surfaces of the photographic material and the diffusing material in contact with which it is placed during measurement. This subject has been treated at great length by Renwick and his collaborators and by many other investigators. For detailed treatments of this subject the reader is referred to the literature.[87] Many of the densitometers which have been developed, especially for use in measuring the density of photographic deposits, employ this principle of placing the deposit, while being measured, in contact with a diffusing medium. While no official standard method of measuring density has ever been adopted by an authoritative body, it seems probable that this method represents best practice where it is desired to measure the density value based upon total transmission and a value which very closely approximates the effective contact printing density.

Special Forms of Densitometers.—Many different types of densitometers have been designed and used by workers in the field of photographic sensitometry. No attempt will be made in the present treatment of the subject to give complete references to all of these. Mention will be made of a few which illustrate types and which will serve to give the reader some idea of the general principles involved in the design and construction of such instruments.

A very convenient form of bench photometer is that developed by Ferguson, Renwick, and Benson.[88] The light source and the photometer head in this instrument occupy fixed positions relative to each other. The balancing of the photometric field is obtained by means of sliding mirrors which vary the effective distance between the light source and one-half of the photometric field. This instrument uses a fixed light source, although in a later design by Ferguson two light sources are incorporated and so arranged that the brightness of the photometric field remains constant regardless of the density of the photographic image being measured. This arrangement has certain arguments in its favor although, if care is exercised to maintain a field brightness within certain limits, such precaution as maintaining a constant field brightness seems to be quite unnecessary.

Another instrument which may be classified as the bench photometer type is that of Capstaff and Green.[89] This was designed particularly for the measurement of very small areas so that the distribution of density in a single motion picture frame may be isolated and measured. A diagram showing the arrangement of the essential parts of this instrument is shown in Fig. 35. The light

source, I, moves up and down on a suitable carriage which is driven by means of a steel ribbon stretched over two rolls, as seen at the top and bottom of the extreme left of the drawing. This steel tape is graduated and a suitable reading device serves to indicate the position of the lamp at any instant. The diffusing screens, S and S', are located as shown. The light source, I, moves back and forth between these two screens. As the source moves upward the illumination on the

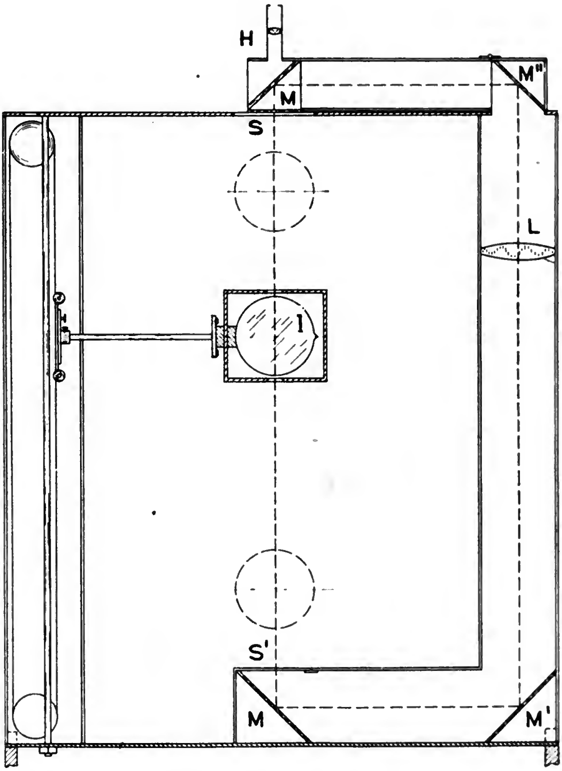

FIG. 35. Schematic diagram illustrating the design of the Capstaff-Green densitometer.

screen, S, increases, while that on S' decreases, and *vice versa*. The illumination on both screens at any instant can be computed directly by the inverse square law. The photometer head, H, consists essentially of a cubical enclosure with a mirror fixed across it diagonally as shown. The photographic image to be measured is laid on top and in contact with the diffusing screen, S, and directly under the photome-

ter head which is hinged to permit the insertion of the density to be measured. An image of the diffusing screen, S', is formed by the lens, L, in the plane of the photometric field, the necessary bending of the light rays being accomplished by the mirrors, M, M', and M''. A detailed view showing the arrangement of the photometer head is shown in Fig. 36. Directly above the diffusing screen, S, and forming the lower surface of the photometer head is a small piece of silvered glass, FM. The lower surface of this glass is silvered and lies in contact with the diffusing screen, S. In the center a circular spot

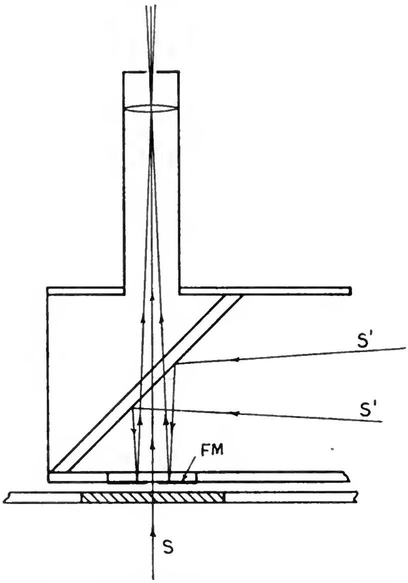

FIG. 36. Photometer head for Capstaff-Green densitometer.

of the silvering about 0.5 mm. in diameter is removed. A plate of clear glass is placed diagonally at 45 degrees as shown. This serves to reflect light coming from the source, S', downward onto the reflecting surface, FM, which, in turn, reflects it upward through the eyepiece of the instrument. The eye of the observer, therefore, sees a field in the center of which is a small spot covered by the photographic density to be measured surrounded by a comparison field illuminated from the source, S'. By moving the lamp, I (Fig. 35), back and forth, a position of balance can be found and a reading on the tape indicates directly the density of the silver deposit. This instrument has been

found very useful, particularly where it is desired to read the density of a very small area.

Another type of instrument designed by Jones,[90] for use in measuring very high photographic densities, is shown in Fig. 37. The light source, *A*, is of the tungsten incandescent type operating at high efficiency, thus giving a high intrinsic brightness. The lens system, *F*, forms an image of this source on the diffusing screen, *M*, in contact with which the photographic density to be measured is placed. The comparison beam is carried around by means of the lens system, *D* and *B*, an image of *A* being formed on the diffusing screen, *H*. The lenses as shown form images of the screens, *M* and *H*, in the Lummer-Brodhun cube, *K*, which is viewed by means of the eyepiece, *I*.

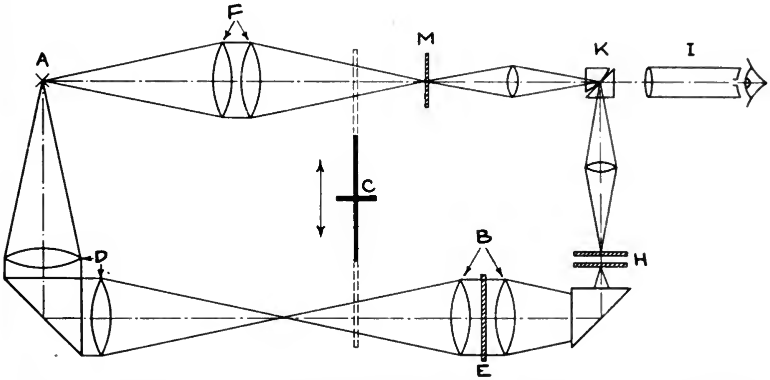

FIG. 37. Schematic diagram showing the optical system of the Jones high intensity densitometer.

Between the components of lens system *B* is mounted a radial sector diaphragm, the transmission of which is directly proportional to the angular position which can be read on a convenient scale calibrated either in transmission or directly in density. With such a radial sector diaphragm, it is impossible to work over a range much greater than 1 to 100, corresponding to a maximum density of 2.0. In order to increase the density range, use is made of the rotating sector, *C*, which may be placed in either of three positions: (1) the neutral position indicated by the solid black lines shown in the figure; (2) moved laterally so as to rotate in the light beam between *A* and *M*; and (3) moved laterally so as to rotate in the comparison beam between the lens systems, *B* and *D*. This rotating sector is so cut as to have an effective density of 1.5. The initial adjustment of the in-

strument is made with the sector, *C*, rotating in the beam between *A* and *M*. The adjustment of intensity balance is made by varying the separation of the two components of the diffusing screen, *H*. The instrument having been balanced for brightness, the photographic density to be read is placed in position and by setting the radial sector diaphragm, *E*, the reading of transmission or density is made. When the density exceeding 2.0 (the limit available with the adjustable radial sector) is encountered, the rotating sector, *C*, is placed in the neutral position and a density value of 1.5 added to all of the readings made directly on the sector, *E*. When a density value exceeding 3.5 is encountered the rotating sector, *C*, is placed into the third position (in the beam between *D* and *B*) and a density of 3 added to that made directly on the adjustable sector, *E*. It is possible to manufacture the various parts of this instrument with sufficient precision so that no calibration is required. Careful checks by means of the inverse square law have shown that the radial sector, *E*, can be relied upon to within the limits of photometric observation of errors up to densities of 2.0, and it is quite easy to cut the rotating sector, *C*, with sufficient precision so that no appreciable error will be introduced.

Many of the densitometers used in photographic sensitometry may be classed under the comparator type, this terminology being used to refer to any instrument in which the measurement of density is made by comparing it with another density which has been calibrated in some primary instrument, such as a bench polarization or radial sector photometer. Among these may be mentioned several of considerable interest. A microdensitometer, devised by Hartmann[91] particularly for astronomical work, is of the microdensitometer type for measuring the density of spectral lines in stellar images. This involves the use of a calibrated neutral gray wedge. Another instrument designed by Renwick[92] is a very convenient form for practical work and involves the use of a calibrated neutral gray wedge. Goldberg[93] has designed a very useful instrument by means of which the characteristic curve may be automatically outlined on suitable coordinate paper by means of a series of points plotted as each photometric setting is made. This instrument also employs a calibrated neutral gray wedge and is of the comparator type. Simple forms of density comparators have been devised by Ferguson[94] and by Capstaff and Purdy,[95] the latter having been described in the *Transactions* of the Society of Motion Picture Engineers. This instrument in-

volves the use of a circular neutral gray wedge made on a photographic plate. This, again, of course, must be calibrated on an instrument of the primary type. The instrument uses a photometer head identical with that described in connection with the Capstaff-Green densitometer and is particularly useful where it is desired to read the density of small images in motion picture work.

Physical Densitometers.—Recent years have seen remarkable advances in the development of physical photometers. This term is used to designate those instruments in which some light-sensitive element, other than the human eye, is used for the determination of the quality of radiant intensity. Various forms of sensitive receivers, such as the thermopile, the selenium cell, the photoelectric cell, the photovoltaic cell, *etc.*, have been used. There seems to be little doubt when these sensitive elements are used under proper conditions very satisfactory instruments for the measurement of density can be constructed. The literature of this subject is very voluminous and no attempt will be made here to give a comprehensive review and description of all the various physical sensitometers and densitometers that have been suggested. Toy and Rawling[96] have utilized a selenium cell in connection with a calibrated neutral tint wedge. By subjecting the selenium cell alternately to light coming through the neutral tint wedge and the silver deposit to be measured, a position may be found for which no change in the deflection of the galvanometer is observed, thus liminating effectively the absolute sensitivity of the cell and employing the very desirable *null* method principle. The instrument, however, must still be regarded as the comparator type, since it relies essentially on the calibration of the wedge which must be accomplished on some instrument of the primary type.

The general principles of physical densitometry have been discussed at some length by G. R. Harrison[97] and he has described in detail a thermoelectric densitometer utilizing a silver-bismuth thermocouple. This instrument appears to have a very high sensitivity and to give readings of great precision. It is particularly adapted, however, to the measurement of the density of very small areas, such as are found in spectroscopic or stellar work.

In some cases these physical densitometers are made self recording, as, for instance, in one of the earliest forms designed by Koch[98] which used a photoelectric cell as a sensitive element. The photoelectric cell current was measured by means of a string electrometer, the image of the string being formed on a moving photographic plate,

thus giving an automatic record of the density which was moved at a continuous low velocity past the measuring slit. This instrument also was designed chiefly for use in the measurement of spectroscopic line images.

More recently a registering microphotometer has been designed by Moll.[99] This instrument uses a thermopile which, in many cases, has advantages over the photoelectric cell as a light-sensitive device.

In considering the design of physical densitometers it should be remembered that such light-sensitive elements as the photoelectric cell and the photovoltaic cell, *etc.*, are sensitive to certain definite wavelengths of radiation. If the photographic image to be measured has any spectral selective absorption characteristics, it is obvious, therefore, that the values of density obtained by means of such light-sensitive elements may be very misleading unless proper compensation is made for their spectral sensitivity. It should be remembered also that the sensitivity of these elements may change appreciably over relatively short periods of time and, furthermore, that the sensitivity from point to point on the sensitive surface of a fixed cell may vary enormously. The ability to amplify the response of these light-sensitive elements makes it possible to build instruments of great sensitivity. There are many pitfalls, however, which must be avoided if consistent results are to be obtained over long periods of time. The thermopile or thermojunction is non-selective in sensitivity and has, therefore, some advantages to offer over those sensitive cells which have selective sensitivity characteristics. It is usually somewhat more sluggish, however, and the defects in amplifying its response are great. The entire question of physical densitometer design is a complicated one but it seems probable that eventually very satisfactory instruments of this type will be evolved and will come into common use in photographic sensitometry.

(*Continued in the January issue of the* JOURNAL)

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DISCUSSION

MR. GRUBER: I should like to ask Mr. Jones about the new sensitometer that Eastman is putting out for use in laboratories. No sensitometers are at present in practical use, excepting those designed by individual workers for their own use. There is one sensitometer which has been designed by the Western Electric Company for measuring sound track densities and the over-all gamma of special prints, but no practical sensitometer for laboratory use has been put on the market so far, that I know of.

MR. JONES: For a complete description of this sensitometer reference should be made to another paper (*J. Soc. Mot. Pict. Eng.*, Oct., 1931).

MR. HARDY: Referring to the illustration in which a collimated beam was shown, would the density be any different with this beam than with the diffuse beam?

MR. JONES: In making measurements of diffuse density (it being understood that the term is used in reference to the value of density based upon the total transmission of the developed silver image) it makes no difference whether the sample is illuminated by completely diffused radiation or by a specular beam.

This statement is true in case the measurement of diffuse density is made by means of an integrating sphere, and also applies to the case where the value of diffuse density is made by placing the developed silver image in contact with a material which causes complete diffusion of the transmitted radiation. In order to measure specular transmission the silver deposit in question must, of course, be illuminated by a specular or collimated beam.

MR. FRAYNE: I should like to call attention to the fact that the new Western Electric densitometer, which is of the polarization type, manufactured by the Bausch & Lomb Co., permits densities as high as 4 to be read. I believe Mr. Jones stated that 2 or $2^1/_2$ is as high as could be read accurately on any densitometer.

MR. JONES: I do not wish my statement to be misunderstood. It was intended to apply primarily to the Martens polarization photometer head as manufactured by Schmidt & Haensch, and as is usually used. Now, it is perfectly true that by modifying the structure, especially the structure within the nosepiece of the instrument, by a series of diaphragms to shield out scattered light, this instrument can be made to read very precisely up to higher densities, but I was referring to the usual commercial form. Undoubtedly this instrument can be improved. I do not have any information on the instrument referred to by Mr. Frayne, but he is undoubtedly correct in his assertions.

MR. MACKENZIE: The gentleman who made the instrument for measuring the higher densities is present. I believe it would be very interesting if Mr. Herriott could explain how it was done.

MR. HERRIOTT: In endeavoring to provide a densitometer that would give satisfactory readings at higher densities, we had to give consideration to the type of sensitometer that was then being used to some extent in the field. That instrument was of the table type, and the scale of intensities was of the order of 1 to 1000. Now in order to individually calibrate the tablet used, it was felt desirable to have available a densitometer that would read up to 3 with fair precision. An examination of several densitometers of the Bell Laboratories indicated two things—first, that the illumination was usually insufficient to enable one to make precise settings at these lower transmissions; and second, that the instrument suffered by reason of the flare that exists in the commercial densitometers. In the particular instrument in question, namely, the Bausch & Lomb, mentioned by Mr. Frayne, we found that this flare was quite serious. In endeavoring to read densities of the order of 3 or 4, we erred as much as 0.5. In all cases the measured density was much less than the true value because of the superposition of flare. Analysis of the difficulty led us to believe that by a change of the interfacial angle of the polarization prism we could deflect a flare image which was superposed on the field by the introduction of a small angle on the polarizing prism, and we found that we had almost completely eliminated the flare so that a comparison of density readings made on that instrument with standard calibrated tablets indicated that the error in density was of the order of 2 or 3 per cent up to a density value of 4. We have since determined that we can improve the instrument somewhat from the standpoint of illumination by using thinner diffusing screens. We recognize, of course, that the need of reading these relatively high densities is not directly involved in sound track sensitometry, but from the standpoint of a tablet type of sensitometer we considered it quite important.

MR. FRAYNE: Will Mr. Jones please explain in some detail the origin of color, and the method of suppressing it by photographic formulas?

MR. HICKMAN: I should like to ask Mr. Jones if the P-A-P developer has shown a number of characteristics which make it superior for all other test purposes. What is to prevent it from coming into commercial use for film processing?

PRESIDENT CRABTREE: Up to within recently it has been difficult to obtain pure samples of P-A-P. They are now available and there is no reason why they should not be used. Of course, in the developer formula it is necessary to use three or four times the quantity of P-A-P as of Elon for the same developing energy, in order to obtain the same reduction potential. It is a rather uneconomical developer, but it has the advantage that at high temperature it gives a minimum of fog. What is the source of color?

MR. JONES: There may be several reasons for the selective absorption. In the case of the particular developer I discussed, it is due almost completely to a staining of the gelatin immediately surrounding the developed grain by the reaction products of development. Selective absorption may, however, arise from other sources. For instance, selective scatter of transmitted light may follow as a result of particle size in the developed image. This subject of selective scatter has been treated at length by Raleigh in various of his papers on this subject. It is quite possible by adjusting the development formula to obtain deposit differing widely in color difference, color depending almost entirely upon selective scatter due to grain size. The control of grain size is frequently used in obtaining desired tones in a silver deposit. It is difficult to make any general statement relative to the source of selective absorption without a careful study of the specific conditions existing during development. Certain developers exist which during development form reaction products that are blue in color. This may be absorbed in the gelatin around the developed grains and give rise to a color index value less than unity. However, anything which produces selective absorption will, of course, cause density values as measured visually to differ from density values as measured photographically, and hence from the effective printing density values. As indicated in Table X the color index of a pyro developed image may be as high as 2.75 when the sulfite is omitted entirely from the formula. It is possible by proper treatment of such a negative to remove all the metallic silver without disturbing colored material which has been absorbed by the gelatin. A negative treated in this manner may produce a perfectly satisfactory print on ordinarily positive materials which are sensitive only to blue light, the image of course being due entirely to the yellow stain in the negative.

MR. FRAYNE: Does the color coefficient remain constant in value over the developed life of the bath?

MR. JONES: It may or may not, depending on the constitution of the bath and what happens as the developer does its work. Of course, in sensitometry we always use large volumes of developer for the development of the strip as compared with the amount of work it has to do. Under those conditions we can safely assume that the color coefficient will be independent of the life of the bath. In practice, where a large amount of film is developed, an appreciable change in the developer constitution occurs as a result of the reaction, and the color coefficient may therefore change with the life of the bath.

PRESIDENT CRABTREE: I should say that the color index would change with

exhaustion. Of course, the bromide which accumulates remains in the bath with the other products of development. They stain the image and prolong the time of development, which, of course, determines the grain size, which determines, in turn, the selective absorption, so that we can expect a slight change with exhaustion. One of the difficulties of commercial work is the task of maintaining the properties of the developer constant throughout its life. That is why there is a tendency on the part of the older workers to reserve a fraction of the old developer to mix with the new, so that the change from old to new would be as small as possible.

MR. GRUBER: I should like to ask Mr. Jones how the densities are read in practice. Experience has taught me that in reading densities much lower than 2 or 3, the density of sensitometric strip changes in the reading, and the reading has to be done quite rapidly. It changes in some cases to such an extent that it is necessary to put in a light of much lower intensity in order to get the exact readings. For readings of densities as high as 3 or 4, the light source must be 3 or 4 times stronger and that would affect the density.

MR. JONES: I must confess to a lack of experience in reading wet sensitometric strips but I can perhaps explain the changes which occur. It is well known that the density values obtained by reading a wet strip differ appreciably from those obtained from the same strip after drying. To understand what occurs let us consider for a moment the character of the silver image in the wet and dry states. When wet the gelatin film is probably ten times as thick as the same film after being dried. The developed silver grains are distributed more or less uniformly through this thickness and in many cases these grains tend to have a thin, plate-like form. The orientation of these grains with the gelatin in a wet and swollen condition follows quite closely a probability law, but as the layer becomes thinner due to drying there is a marked tendency for the plate-like grains to flatten out and lie more nearly parallel with the surface of the support. Such an action would tend to make the effective projection area of the silver grains greater in the dry than in the wet condition, and therefore the densities as read on the dry strip should be somewhat higher than those read on the wet strip. The problem of the orientation of the silver halide and the developed silver grains in the gelatin matrix has been treated by Ludwik Silberstein.

It seems probable that in the reading of wet strips the rather high energy flux which must be used in order to give adequate illumination will tend to cause the drying process to proceed more or less rapidly during the reading operation. The error may therefore be variable under various conditions, and difficult to evaluate. It might be possible to eliminate this variable change of drying, in reading the wet strips, by placing between the light source and the wet strip a cell containing a solution of copper sulfate for the absorption of the greater proportion of the heat, thus preventing to a certain extent the drying of the strip during the reading of density.

PRESIDENT CRABTREE: With regard to the standard developer formula which is being presented at the International Congress, that formula was devised for development at high temperatures. It has a high concentration of sulfite and carbonate and in a fairly strong solution of gelatin it does not swell. Even at high temperatures it can be handled satisfactorily for motion picture work. There is a tendency now for even the professional photographers to use the

borax formula for cut films, in addition to the motion picture workers, so that it would seem to me to be desirable for the Congress to consider the borax type of formula, or a mixture of borax and alkali which is called the buffered formula. Do you have the color coefficient values of the borax formula?

MR. JONES: I hesitate to give those values from memory. We have measured them, but I do not have them with me.

PRESIDENT CRABTREE: I believe the values are around 1.1 or 1.15.

MR. JONES: The values are very low—about 1.2 so far as I can remember.

MR. GRUBER: I should like to know how the borax may be used to raise the *p*H of the solution or of any of its characteristics that may aid in the development.

PRESIDENT CRABTREE: One way is to change the *p*H of the bath. This permits one to use a bath of high *p*H and still have a large reserve of alkali, so that as the alkali becomes neutralized during the development process, more of the borax hydrolizes, and more alkali is made available.

DUNNING PROCESS AND PROCESS BACKGROUNDS*

CARROLL H. DUNNING**

Summary.—*The paper includes a description of the general principles of the Dunning process and methods of processing backgrounds into motion pictures. It elaborates on a previous paper*[1] *describing the system. Various features to be considered in applying the process and the various difficulties encountered are briefly discussed. The necessity for maintaining the proper height and angle of the camera when taking shots of backgrounds to be processed is emphasized.*

The Dunning Process, described originally in the *Transactions* in 1928,[1] fundamentally is based upon the use of a colored transparent background scene, used in connection with a colored illuminated background behind the actors of the foreground scene during double-exposure. In other words, a transparent positive of the background scene is made from any standard width developed negative. This transparency is loaded in an intermediate magazine placed between the regular raw stock magazine and the camera.

The raw stock passes through the intermediate magazine and into the exposure position in the camera jointly with the transparency contained in the intermediate magazine. The latter is in front of and in contact with the raw stock. This transparency, as made at present, carries an orange image in its shadow positive portions and a neutral negative image in its highlight diapositive portions. This gives it an equal filter absorptive value over its entire area and renders it an equivalent to a heavy over-all K filter.

Therefore, if actors and all portions of the foreground component of a composite photograph are illuminated with, say, a yellow light, they will be photographed through the transparency representing the background component and their images will be impinged *solidly* upon the raw stock in the same manner as would occur if they were photographed through an over-all K filter. This summarizes the first phase, or consideration, which naturally is to secure a solid

* Presented in the Symposium on Laboratory Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** Dunning Process Co., Hollywood, Calif.

original negative of actors through a given scene without a selective exposure obstruction caused by the transparency placed in front of the raw stock.

The second phase, as practiced now, occurs automatically and simultaneously with the first phase. It is a printing and not a photographic operation. In other words, behind the actors, and preferably out of focus, is a flat wall or curtain illuminated with blue light, approximately complementary to the orange image of the transparency in the camera. This is large enough to act as a printing light for the entire area of the transparency frame, except those portions obstructed momentarily by the actors or foreground set.

The blue light passes through the neutral diapositive portions of the transparency, but unlike the yellow light from the actors, it is absorbed by the orange portions of the transparent background scene. And thus it creates around and apparently behind the actors on the same raw stock a printed contact negative exposure of the background scene. When developed in the ordinary manner, there is found a completed composite negative of the actors in their preselected environment, and projection positives are printed from these in the usual way. The use of orange positive in the camera and the blue background behind the actors is not at all compulsory. Good results may be obtained by the use of other complementary colors. These are fully described in the several patents issued to Dodge Dunning and Roy J. Pomeroy, all of which are exclusively licensed to the Dunning Process Co.

PROCESS BACKGROUNDS

All scenes, which are to be used as process backgrounds should be selected with care. Process work is effective only when done well, very important roles being played by the following elements: quality, overemphasis, focus, perspective, angle, the height, and the steadiness.

Quality.—To obtain the best background, one should try for a normal negative, normally developed. Underexposed and overdeveloped negatives are apt to be grainy, and may show even a slight increase of graininess in process work.

Negatives which have been highly over-corrected by using colored filters may appear muddy in landscapes unless the sky areas are well broken up by cloud effects.

Overemphasis.—Halation is another fault of such negatives. Overexposed negatives often have so much contrast that it becomes very

difficult to avoid phantom effects; that is, the highlights of the transparency may be so empty as to make it difficult to obtain a value for the absorption filter for the diapositive portions which will correspond to the shadows of the positive portions in the transparency.

Focus.—This is an important point when shooting backgrounds. Some argue, and quite rightly, that all close-ups and medium shots in straight photography show a background either out of focus or blurred. Others claim that such results are due simply to the inherent limitations of ordinary photography, and need not be duplicated if they can be overcome by process photography. Those who pay the bills are apt to say, "We are paying you for putting in backgrounds; we should like to see them." When the eye is focused on a near-by object it does not see the distant scene simultaneously; but it momentarily and rapidly focuses from one plane to another and registers a composite sharp impression of planes at all distances from it.

Experience shows that it is best to shoot a background scene focused comparatively sharply; and then, if necessary, to soften it either by printing by optical means when making the transparency, or by controlling the illumination when making the double-exposure. Therefore, all backgrounds should be focused from 25 feet to infinity. Fifty-mm. lenses are used in most cases.

Perspective.—The most important accessories required when shooting backgrounds are an excellent imagination and a bevel protractor obtainable at any hardware store. The cameraman should see, in his mind's eye, the foreground action that is later to be incorporated into the composite picture. Perhaps it is to be a scene showing a ten-foot length of steamer deck backed by a railing, with the rolling ocean beyond doubled in. Several passengers are to be placed in steamer chairs, and two lovers are going to lean on the railing. Although the camera is directed over the railing of the boat from which he is photographing nothing but an empty ocean, the cameraman must envision the scene we have described as if it were actually before him. He should realize that such a foreground scene, shot later on a stage, will occupy at least the lower half of the finished picture. By placing the bevel protractor along the top of the camera, he will find that it is tipped down perhaps ten degrees and that the distant horizon is about three fourths up from the bottom of the picture. This means that the finished picture will include deck action in the lower half, ocean in the next quarter, and sky in the remaining quarter.

When the foreground is doubled later on the stage, the camera must be set at the same angle, in this case, ten degrees, for if it were placed horizontally, the picture obtained would show a horizontal ship steaming on an ocean running uphill into the horizon. On the other hand, if the background were shot with the camera horizontal, and with the horizon below the center, there would be no ocean in the finished picture.

Every form of transportation is utilized in the changing scenes of motion picture stories, and for this reason there is a demand for moving backgrounds, such as landscapes from train windows, buses, aeroplanes, taxis, *etc.* The average length of such backgrounds should be at least one hundred feet, or enough for about a minute of dialog and action. Most sequences can be covered within that length.

Angle.—The favorite form of shot used for running street scenes is the straight rearward receding shot. This permits shooting into the faces of the actors when doubling in the foreground action. Forward shots are preferable for thrills because they furnish the audience with a sense of impending danger. Shots taken at right angles to the line of travel are excellent for enhancing the illusion of speed. It must always be remembered that the angle of tilt of the background camera must be duplicated when doubling in the foreground action.

When photographing a rearward receding background, one should not shoot diagonally across the car on the stage merely because the director wants to play his action in that fashion. If that is done, the car will appear to skid sideward throughout the whole length of the finished picture.

Height.—It is very important that the height of the lens above the ground be taken into consideration. For example, in a taxicab shot it is not possible to use a background that has been taken from the top of a bus. A shot such as the latter would show the roofs of all the cars following, which naturally could not be seen from the rear window of a taxi. The best lens height for auto shots is six feet from the ground. The camera should be tilted slightly downward so as to bring the interesting part of the background picture into the upper half where it will be seen through the rear window of the car. Having established the angle, height, and tilt, the background is photographed without panning or without making any other changes. Close-ups and medium shots of foreground action can be made with the same transparency.

Steadiness.—A camera used for photographing backgrounds should

be driven by motor. The exposure fluctuations due to hand cranking are very noticeable when doubled into a foreground action photographed with a motor driven camera.

Weave, caused by hand cranking, loose free heads, strained internal mechanisms, and unsteady tripods spoil to a great extent the effectiveness of process shots.

Camera mechanisms should be tested for steadiness, clamps should be used on free heads, little jacks should be used under the front and back of the camera, and the tripod should be chained down if possible, for all stationary shots.

REFERENCE

[1] DUNNING, CARROLL: "Composite Photography," *Trans. Soc. Mot. Pict. Eng.* (1928), No. 36, p. 975, and DUNNING, CARROLL: "Typical Problems in Process Photography, "*Trans. Soc. Mot. Pict. Eng.* (1929), No. 38, p. 298.

DISCUSSION

MR. GRUBER: Can this process be used in color photography?

MR. DUNNING: Not in its present form, as the process is based on the separation of colors. But we are working on a method now to be used for color photography.

PRESIDENT CRABTREE: When inserting whispering sounds against the background noise, do you make the mat of the background noise in orange and then print in the sound as in the case of the picture?

MR. DUNNING: The dialog portion of the composite picture has no bearing on composite photography. As you know, the dialog record is on a separate track, and is printed in the empty space alongside the composite picture. Neither kind nor quality of sound has anything to do with composite photography, as the former is merely a printing operation which is done after the composite negative is finished. In producing a German version recently, we went to Germany armed with all the mechanical means of simulating the desired noises to prevent duplication of the recording of those sounds, and they were dubbed into the picture wherever necessary and as desired. An element that is quite important is the fact that extraneous noise can be controlled by this method. If a couple on a street corner were conversing, the dialog could be recorded on a stage synchronously with the photographing of the composite picture; such sounds can be "dubbed in" as should be interspersed between the spoken sentences without interfering with the dialog.

MR. GOLDEN: Can you approximate the costs involved in a given picture?

MR. DUNNING: In the picture in question, which cost six hundred thousand dollars, the entire cost of the German version, including our processes, actors, sound recording, rental of stage, and expenses to Germany was $30,000 for each version. *The Subway Express* is a processed picture from its main title to its end. The entire action occurs inside a subway car, and the action outside the window, showing the train going from 40 to 125 miles an hour is processed into the picture.

This was done with a carefully worked-out set of moving backgrounds; the train starting and getting up to full speed, was shown on one plate; another plate was made of the transparency of the passing trains; another of the flying stations; and another of the train going at full speed down to a standstill. One was made at right angles 45 degrees to the rear and another at 45 degrees forward, and all were pieced together and cataloged. Four sets of each plate were made for four magazines and the picture was shot in twenty-one days. A picture which would be simple in character could be done in less time.

MR. PALMER: I should like to ask you to define again the characteristics of the orange transparency. If I remember correctly, you described it as a positive in the shadowy section and as a dyed diapositive in the highlight sections. Is there any difference between that and ordinary light printed positive?

MR. DUNNING: Yes, by all means. You will have to assume that the processing consists of two separate operations. Suppose you take a picture of a man in front of a blue backing, and shoot straight onto panchromatic raw stock. The blue backing would naturally turn the negative black in the portions not occupied by the man. If you should introduce a 15 filter or heavy *K* filter across the entire aperture in contact with the raw stock you would still get a negative of the blue background and the normal negative of the man. That would give a solid man on the film. Now let us assume that instead of the 15 filter across the raw stock and in contact with it in front, you should mount it so that it would cover the lower half of the picture in the shape of mountain peaks. You then would have a 15 filter across the bottom and an emphasis across the top. On photographing a man through it, the result would indicate the difference between ordinary photography and filter photography; the phantom of a mountain across the man would be obtained. You would not get as much exposure through the filtered lower part as the top was passing directly onto the film. The lower orange filter represents the positive shadow portions of the background scene, and the upper sky filter represents what I have called the diapositive portions.

THE EFFECT OF EXPOSURE AND DEVELOPMENT ON THE QUALITY OF VARIABLE WIDTH PHOTOGRAPHIC SOUND RECORDING*

DONALD FOSTER**

Summary.—*This paper deals with the dependence of the quality of variable width recording on the conditions of exposure and development. When the widths of the images employed in recording or reproducing are comparable with the wavelength of the record the exposed portion of the record is not uniformly exposed. The record is attenuated in amplitude as the frequency is increased, and harmonics are introduced whose relative intensities depend on the contrast of development and on the frequency. When the exposure of the record occupies the linear range of the H & D curve, and when the product of the gammas of the negative and the positive is equal to unity, the record is practically free from spurious harmonics. The amount of non-linear distortion is calculated for the case when the over-all gamma is equal to two; and it is shown that Cook's[2] analysis of the aperture effect gives a superior limit to the distortion obtainable by overexposure or by over- or underdevelopment. The effect of the unavoidable non-uniform illumination of the images is considered.*

INTRODUCTION

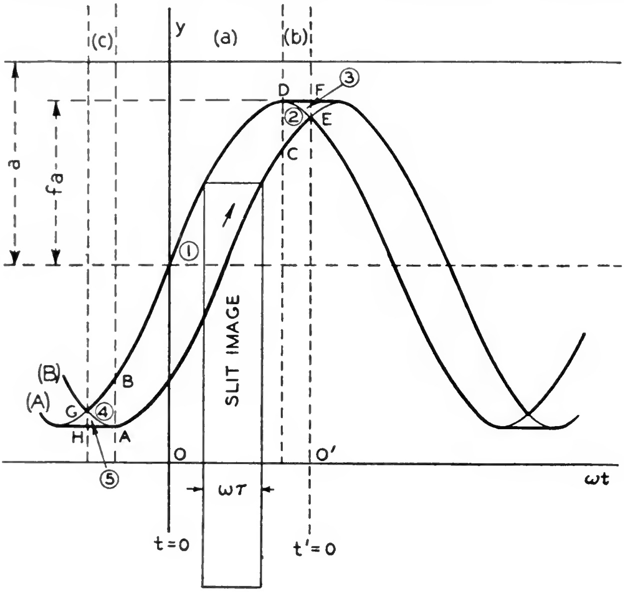
The theory of the variable width method of recording has been discussed in two different papers published previously in this JOURNAL. A. C. Hardy's[1] analysis of this method of recording was based on the assumption that the width of the image is small compared with the wavelength of the record. Under this assumption, Hardy finds that the quality of the sound reproduced does not depend on the conditions of exposure or development of either the negative or the positive. Cook,[2] on the other hand, considers the case where the ratio of width of image to wavelength is finite. It is further assumed that wherever light falls on the film it is fully exposed. Under these assumptions it is found that harmonics of rather high intensity relative to the fundamental are produced. The following analysis is made without the above simplifying assumptions, and considers the more general case where the density of any point of the record is

* Presented in the Symposium on Laboratory Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** Bell Telephone Laboratories, New York, N. Y.

determined by both the exposure and the contrast of the development. It is particularly interesting to note that the analysis shows that if the negative and positive records are developed to an over-all gamma of unity practically no harmonics are introduced, as is the case with the variable density record. As the records are developed to higher or lower contrasts, the condition with regard to harmonics approaches that considered by Cook.

In attempting a more exact theory of the process, the most im-



CURVE (A): $y = a + fa \sin \omega t$

CURVE (B): $y = a + fa \sin (\omega t - \omega \tau)$

$\tau = W/V$, THE TIME TO GO ACROSS THE SLIT IMAGE

FIG. 1. Path of the recording image on the film when recording a pure tone.

portant factor previously neglected which is capable of analytical treatment is the non-uniform blackening of the exposed part of the negative due to the finite width of the recording aperture. In fact, it is this non-uniform exposure that leads to the possibility of obtaining a record that is practically free from non-linear distortion. It is doubtless true that at high frequencies the limitation imposed by the physical characteristics of the film is of importance; but in this paper attention will be confined to the influence of slit-width. It will

be convenient also to consider the effect of the width of the reproducing slit-image upon the reproduced sound. The latter discussion is applicable to either the variable width or the variable density type of record.

STATEMENT OF THE PROBLEM

We begin by supposing that the image of the recording aperture on the sound track is rectangular in shape, of width w and length y, that it is uniformly illuminated, and that the film moves with a constant velocity, v. The oscillatory motion of the image due to recording of sound is perpendicular to the steady motion of the film. Under these circumstances the exposed portion of the sound track will not be uniformly exposed because certain points on the film will not pass over the full width of the image. The duration of exposure is proportional to the component of displacement of the point crosswise of the image. The way in which the sound track is exposed when the oscillation of the image is simple harmonic is seen in Fig. 1.

The curves (A) and (B) are two sine curves which represent the loci of the corners of the image on the sound track. In the region above the heavy line, $GBDF$, there is no exposure. Below the other heavy line, $ECAH$, all points pass completely across the image, and exposure is uniform. Exposure between these two boundaries is non-uniform and varies from nothing at the upper boundary to that of the uniform region at the lower boundary. Transit of a point across the image may occur in three different ways, as shown in Fig. 2. The curves drawn across the images are the loci, relative to the image, of the representative points, P, P', P''. Thus it is seen that the sound track is made up of: (1) a uniformly exposed region bounded by a curve having sharp peaks and flat valleys; (2) an unexposed region similarly bounded; and (3) a non-uniform region between (1) and (2). The problem is to calculate the light transmitted by the sound track along a transverse line. The effect of using a reproducing slit of finite width will then be deduced.

SOLUTION

Assume that the non-uniform part of the record is exposed and printed in the linear range of the H & D curve. Strictly, the zero limit of exposure at the upper boundary (Fig. 1) requires the existence of a relatively narrow band there which cannot satisfy the condition of linearity for any intensity of the light. Neglect of this

leads to a small error in the calculations for the positive print, but it must be taken into account in calculating the mean transmission of the negative. On account of its greater importance, the discussion is confined here to the problem of the positive. The transmission, T, of a point on the positive may be written

$$T = K E_n^{\gamma} \tag{1}$$

where K is a constant, E_n is the exposure of the negative, and γ is the product of the gammas of the negative and the positive. The ratio of the exposure of a point P in the non-uniform region to that of the uniformly exposed region is

$$\frac{\phi}{\omega\tau}$$

where $\omega\tau$ is the phase-difference of the two sides of the image and ϕ

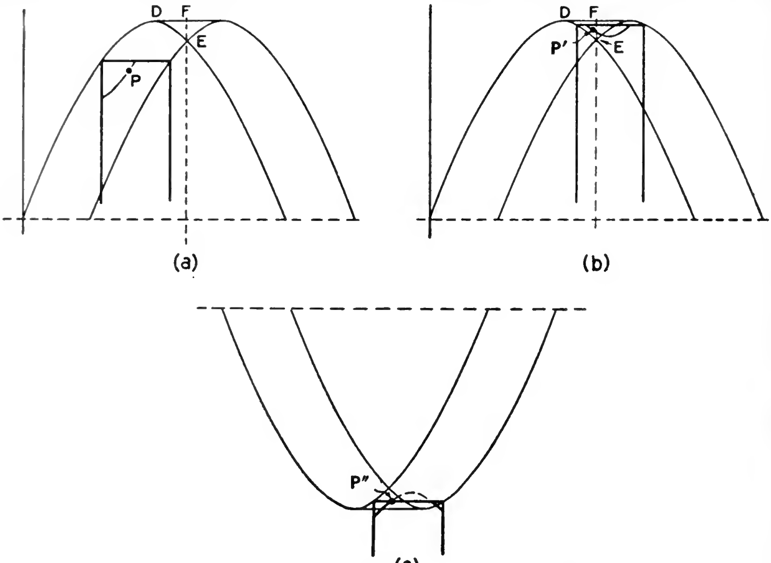


FIG. 2. Exposure produced in different regions of the record.

is the phase-increment of the point P while being exposed. From eq. (1) it follows that the transmission at P in terms of that of the uniform region is

$$T = T' \left(\frac{\phi}{\omega\tau}\right)^{\gamma} \tag{2}$$

The amount of light transmitted by an element of area at P of

chosen small width, μ, is proportional to $\mu T \delta y$. Changing the variable by means of the relation

$$\delta y\Big]_{\omega t} = -af \cos(\omega t - \theta)\,\delta\theta \tag{3}$$

in which f is the modulation and θ is the epoch of the sine curve through P, $y = a + af \sin(\omega t - \theta)$. Integrating, the total light transmitted by the non-uniform region reaching along the y coordinate from $y = A$ to $y = B$ is proportional to

$$\mu \int_A^B T\,\delta y = T'\mu \int_\alpha^\beta \left(\frac{\varphi}{\omega\tau}\right)^\gamma \{-af \cos(\omega t - \theta)\}\,d\theta \tag{4}$$

where α and β are the values of θ corresponding to the limits A and B of y. The quantity under the integral sign is interpreted as the height of a uniformly exposed strip of transmission T' which will transmit the same amount of light as the non-uniform strip under consideration. The function

$$\begin{aligned} h_i &\equiv \int_{\alpha i}^{\beta i} \left(\frac{\phi_i}{\omega\tau}\right)^\gamma \{-af \cos(\omega t - \theta)\}\,d\theta \\ &= -af(\omega\tau)^{-\gamma} \int_{\alpha i}^{\beta i} \varphi_i{}^\gamma \cos(\omega t - \theta)\,d\theta \end{aligned} \tag{5}$$

is therefore the one which is to be calculated for the different regions and summed for the entire width of the sound track. The subscript, i, takes on the values 1 to 5, the significations of which are indicated by the numbered areas of Fig. 1. The symbols, h' and h'', will designate the corresponding functions for the uniformly exposed and unexposed regions, respectively.

Evaluation of the transmission of the sound track by this general method leads to lengthy calculations. It is possible, however, to demonstrate here quite simply what the result is for the special case, $\gamma = 1$. In that case the transmission is proportional to the exposure. Thus the mean transmission of a narrow transverse strip is proportional to the mean exposure of the strip. Consider the recording image as made up of a number of very narrow images of equal width side by side. By a proposition on the composition of vibrations,* the vector sum of the products of the amplitude and exposure due to all these elementary images is the same as though the

* See, for instance, PRESTON: "Theory of Light," § 45. The problem is identical mathematically with that of the diffraction of plane waves through a rectangular aperture.

record were made by an infinitely narrow image in which all the light is concentrated and has a phase equal to that of the middle of the actual image. The amplitude is equal to that of the elementary images multiplied by $\dfrac{\sin\frac{\omega\tau}{2}}{\frac{\omega\tau}{2}}$ where $\omega\tau$ is the phase-difference of the extreme edges of the finite image. Thus, we see at once that when the product of the gammas is equal to one there is no non-linear distortion; and, using the same notation as before, the equivalent amplitude and phase for the whole exposed part of the record are given by

$$h = a + \frac{\sin\frac{\omega\tau}{2}}{\frac{\omega\tau}{2}}\, af \sin\left(\omega t + \frac{\omega\tau}{2}\right) \tag{6}$$

This may be put in the more convenient form

$$h = a + \frac{\sin \epsilon}{\epsilon}\, af \cos \omega t' \tag{7}$$

where $\epsilon \equiv \dfrac{\omega\tau}{2}$; and $\omega t \equiv \omega t' + \dfrac{\pi + \omega\tau}{2}$. (The origin of the new co-ordinate, $\omega t'$, is seen in Fig. 1.) The number ϵ is related to the frequency, width of image, and velocity of the film by the equation

$$\epsilon = \frac{2\pi n\tau}{2} = \pi n \frac{w}{v}$$

where n is the frequency. Or, we may write

$$\epsilon = \pi \frac{w}{\lambda}$$

where λ is the wavelength of the record. The amplitude recorded eq. (7) is less than the applied amplitude by the factor $\dfrac{\sin \epsilon}{\epsilon} \equiv A$ which is shown plotted against ϵ in Fig. 3.

While eq. (7) shows that the exposed part is free from non-linear distortion, it is not to be inferred that this equation applies to the sound track as a whole. The unexposed part of the track is relatively dense in the positive, yet it will transmit a little light and it is apparent from the irregular nature of its lower boundary (*GBDF*, Fig. 1) that this part of the track will contribute harmonics. The

calculation of h for the unexposed part is, of course, quite independent of what value may be assigned to γ.

When the height of the dark part of the record is expressed as a series of harmonics, we obtain

$$\begin{aligned} h'' &= \text{const.} + B\,af\cos\omega t' \\ &\quad + C\,af\cos 2\omega t' + etc. \end{aligned} \tag{8}$$

in which the const. term and the coefficients B, C, *etc.*, are functions of ϵ. This part of the record has a uniform transmission T'' which is

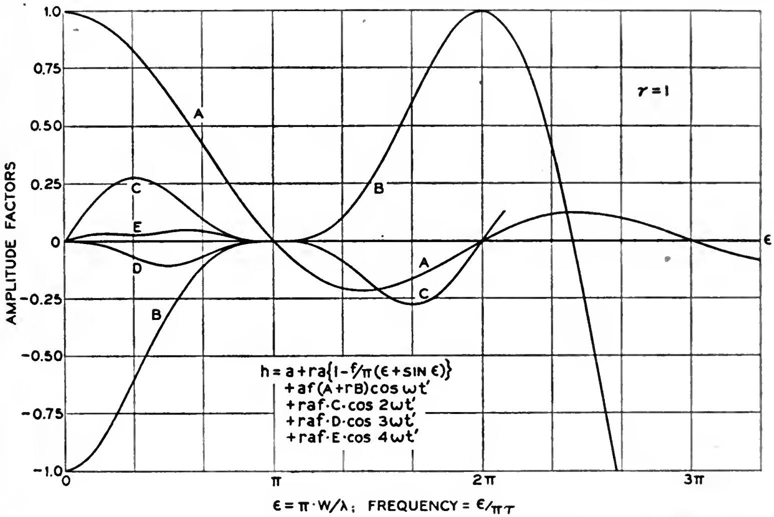


FIG. 3. These curves show the variation with frequency of certain functions which enter into the equations for the amplitudes of the record. The equation which holds when $\gamma = 1$ is shown.

less than the transmission of the uniformly exposed part by the factor $r \equiv \dfrac{T''}{T'}\cdot$ The amount of light transmitted by the unexposed part is proportional to $T''h''$ which may be written $T'\,(rh'')$. Thus, for the whole record the height of the equivalent uniform track of transmission T' is

$$\begin{aligned} H &= h + rh'' \\ &= [a + ra\{1 - \frac{f}{\pi}(\epsilon + \sin\epsilon)\}] + af(A + rB)\cos\omega t' \\ &\quad + raf\,C\cos 2\,\omega t' + etc. \end{aligned} \tag{9}$$

The limit of eq. (9) as the frequency approaches zero ($\epsilon \doteq 0$) is

$$H = a(1 + r) + af(1 - r)\cos\omega t'$$

Note that the effect of increasing r is to diminish the amplitude of the first harmonic. The maximum modulation at low frequency ($\epsilon \doteq 0$) is

$$M = \frac{af(1-r)}{a(1+r)} = f\left(\frac{1-r}{1+r}\right) = \left(\frac{T' - T''}{T' + T''}\right)f \tag{10}$$

The coefficients, A, B, *etc.*, of eq. (9) are functions of the frequency through the variable ϵ, and they have been calculated at 15-degree intervals of ϵ. The curves of Fig. 3 show the influence of frequency on these amplitude factors. These curves are, of course, applicable to any speed of the film and to any width of the recording image because they are calculated in terms of the dimensionless number ϵ. For example, when the film speed is 18 inches per second and the image-width is 0.002 inch, the time τ is equal to $\frac{0.002}{18}$ second, so that when $\epsilon = \pi$,

$$n = \frac{18}{0.002} = 9000 \text{ cycles per second}$$

As has been remarked before, A is the only one of the curves which depends on the value chosen for gamma.

At this point it is of interest to estimate the relative intensities of the various harmonics. If the exposure is largely confined to the straight line portion of the curve of the emulsion, as has been assumed, the density of the positive corresponding to the unexposed negative may be taken to be about 2, while the density corresponding to the exposed part may be in the vicinity of 0.4. The ratio of the transmissions will then be

$$r = \frac{T''}{T'} = \frac{10^{D'}}{10^{D''}} = 10^{D'-D''} = 10^{-1.6}$$

Choosing the frequency for which the ratio of the amplitude of the second harmonic to that of the first is greatest, the ratio of the amplitudes of the first two harmonics is found to be

$$R = \frac{rcf\ C}{af(A + rB)} = r\frac{C}{A}\left(1 - r\frac{B}{A} + r^2\frac{B^2}{A^2} - \dots\right)$$
$$= r\frac{C}{A}; \text{ (when } r \text{ is small)} = r \times 0.35$$

which in this case amounts to

$$10^{-1.6} \times 0.35 = 10^{-2.06}$$

The power of the second harmonic is therefore below the level of that

of the first by at least $20 \times 2.06 = 40$ decibels. The second and higher harmonics are negligible under these circumstances, and we may state as a general conclusion that, for a gamma of unity, the record is practically free from non-linear distortion. The amplitude *vs.* frequency characteristic has been calculated for the record; the next problem is to find the relation between the record and the amount of light transmitted by it through a reproducing aperture of finite width.

EFFECT OF IMAGE WIDTH IN REPRODUCING

Let the recorded wave on the film be expressed by

$$y = a_o + \sum_{n=1}^{n=\infty} a_n \sin n\,(\omega t) + \sum_{n=1}^{n=\infty} b_n \cos n\,(\omega t) \tag{11}$$

then the reproduced wave, when the reproducing image is uniformly illuminated and has a phase-width of $2\,\epsilon'$, is given by

$$\begin{aligned}\bar{y} &= \frac{1}{2\epsilon'}\int_{\omega t-\epsilon'}^{\omega t+\epsilon'} y\,d\,(\omega t)\\ &= a'_o + \sum_{n=1}^{n=\infty} a'_n \sin n\,(\omega t) + \sum_{n=1}^{n=\infty} b'_n \cos n\,(\omega t)\end{aligned} \tag{12}$$

where

$$\begin{aligned}a'_o &= a_{o1}\\ a'_n &= a_n \frac{\sin n\,\epsilon'}{n\epsilon'}\\ b_n' &= b_n \frac{\sin n\epsilon'}{n\epsilon'}\end{aligned} \tag{13}$$

For the first harmonic the attenuation factor for reproducing is the same in form as it is for recording; and when the images are of equal width the factors are identical. All harmonics then have their first cut-off at the same frequency of reproduced sound.

The total loss of amplitude involved in both recording and reproducing, with images of equal width, is given in the following equation for the reproduced wave:

$$H_r = a + ra\left\{1 - \frac{f}{\pi}(\epsilon + \sin\epsilon)\right\} + af\,(A + rB)\,A \cos\omega t \tag{14}$$
$$+ \text{ negligible harmonics}$$

in which the term rB is inappreciable, so that approximately

$$H_r = a + ra\left\{1 - \frac{f}{\pi}(\epsilon + \sin\epsilon)\right\} + af\,A^2 \cos\omega t \tag{15}$$

The function $A^2 = \frac{\sin^2 \epsilon}{\epsilon^2}$ is plotted in Fig. 4, and again on a scale of decibels in Fig. 5.

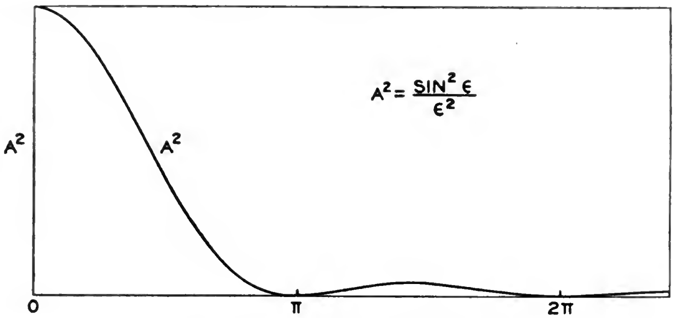


FIG. 4. Dependance of the amplitude of the fundamental of the *reproduced* record on the frequency when recording and reproducing images are of equal width. Curve applies to $\gamma = 1$ or $\gamma = 2$.

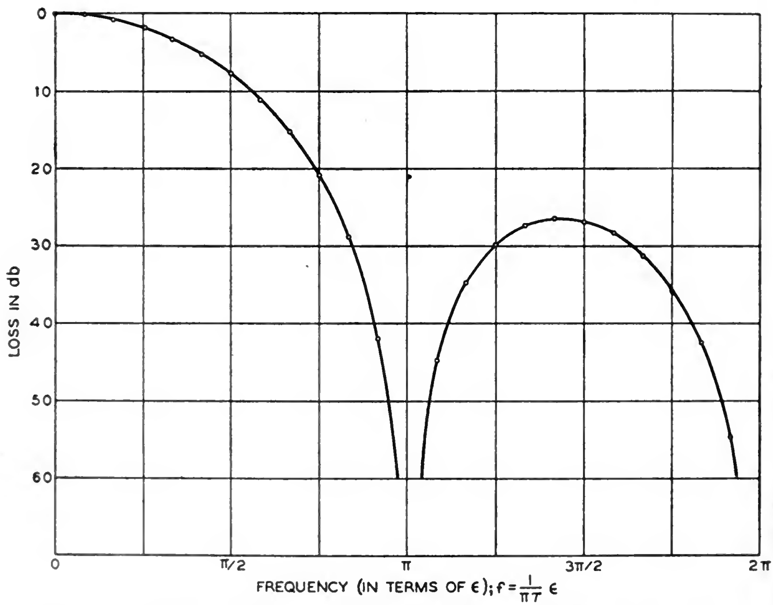


FIG. 5. The information given in Fig. 4 is presented here in terms of decibels.

If the ratio of the slit widths is considerably different from unity the amplitude of the reproduced first harmonic will depend on ϵ in

a manner more nearly represented (as far as the first cut-off) by curve A of Fig. 3. It is the width of the wider aperture which determines the frequency of the first cut-off.

GAMMA NOT EQUAL TO ONE

Before proceeding to the calculation of the distortion when γ is not equal to unity, let us see if we can visualize the effect of development on the wave shape. Referring to Fig. 1, suppose a third coördinate—the transmission, T—be added to this graph so that T is measured upward, normal to the plane of the paper. Now imagine that Fig. 1 is a contour map of the resulting surface. The unexposed region bounded by the heavy line $GBDF$—is a low plain. The uniformly exposed region below the line $HACE$—is a plateau. The region between these two lines represents an escarpment whose contours de-

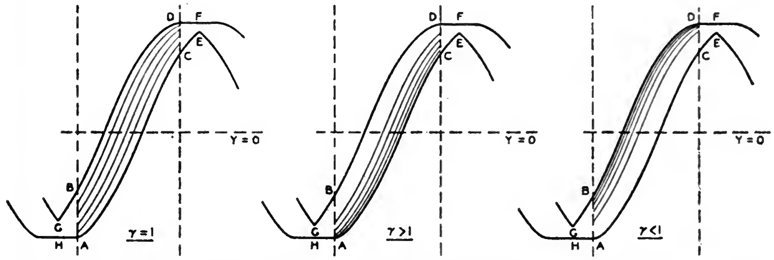


FIG. 6. Contour maps of the transmission of the positive record regarded as a surface.

pend on the development. Consider the intersection of this sloping surface with the vertical plane $y = 0$. The equation of the intersection in the region (a) is evidently eq. (1), which in this case may be written

$$T = k\,\theta^{\gamma} \tag{16}$$

in which k is a constant. This curve is concave upward or downward according as γ is greater or less than one. If γ is equal to one, the section of the escarpment on this plane is a straight line. The contour maps for the three cases are sketched in Fig. 6.

By introducing the function, h, we have supposed the actual transmission surface to be replaced by one in which the sloping surfaces have become vertical. The equivalence of the two records requires that the areas under a vertical section along a transverse line ($\omega t =$ const.) be equal in the two cases. The function, h, defines the sharp

boundary between regions of high and low transmission and is, therefore, representative of the wave shape. Thus, we see that as far as the regions (*a*) are concerned the effect of overdevelopment is to produce sharp peaked waves, while underdevelopment produces broad topped waves. Either condition implies the introduction of harmonics. It is easy to extend these considerations quantitatively so as to obtain graphically a plot of the wave shape for any value of gamma, integral or otherwise. This method also permits allowance for the fact that the *H* and *D* curve is not linear over quite the whole range of exposure.

These considerations lead to the conclusion that for very low gammas or for overexposure the wave shape approaches the curve, *GBDF*, of Fig. 1, while for very high gammas the contour of the equivalent wave approaches as a limit the lower curve, *HACE*. The first curve is the same as that considered by Cook and the variable part of the harmonic series by which the wave may be expressed is identical with that which has been found in this paper for the unexposed part of the record (Fig. 3) if we omit the factor *r*. It may readily be shown that the second curve, *HACE*, is developable into a series of harmonics the variable parts of which are identical with those for the upper curve. It is seen, therefore, that overexposure or development to high or low gammas will not give rise to distortion greater than is given by the special case considered by Cook. It will be shown in what follows, however, that the amplitude *vs.* frequency characteristic of the fundamental is the same for gamma equal to two as it is for gamma equal to one, whereas in the extreme case the characteristic becomes altered and is given by curve *B* of Fig. 3.

The calculation of the shape of the recorded wave and the amplitudes of the harmonic components may be done analytically for integral values of γ. The analysis has been carried out for the case $\gamma = 2$. The functions defining h are not identical for the three phase bands, (*a*), (*b*), (*c*), of Fig. 1 as they were for the case of $\gamma = 1$. Thus it becomes necessary to express the recorded wave as a Fourier series. Calculation of h gives

$$h_c = a + af\left[-\frac{2}{\epsilon^2} + \left\{-\frac{2\cos\epsilon}{\epsilon^2} + (\omega t' + \pi)\frac{\sin\epsilon}{\epsilon^2}\right\}\cos\omega t' + \left\{-\frac{\sin\epsilon}{\epsilon^2} - (\omega t' + \pi)\frac{\cos\epsilon}{\epsilon^2}\right\}\sin\omega t'\right];$$

$$\left[-\pi \leq \omega t' \leq (-\pi + \epsilon)\right] \qquad (17)$$

$$h_a = a + af\left[\frac{\sin\epsilon}{\epsilon}\cos\omega t' + \left(\frac{\sin\epsilon}{\epsilon^2} - \frac{\cos\epsilon}{\epsilon}\right)\sin\omega t'\right];$$

$$\left[(-\pi + \epsilon) \leq \omega t' \leq (-\epsilon)\right] \tag{18}$$

$$h_b = a + af\left[-\frac{2}{\epsilon^2} + \left\{\frac{2\cos\epsilon}{\epsilon^2} + \omega t'\frac{\sin\epsilon}{\epsilon^2} + 2\sin\epsilon\right\}\cos\omega t'\right.$$
$$\left. + \left\{-\frac{\sin\epsilon}{\epsilon^2} + \omega t'\frac{\cos\epsilon}{\epsilon^2}\right\}\sin\omega t'\right];$$

$$\left[(-\epsilon) \leq \omega t' \leq 0\right] \tag{19}$$

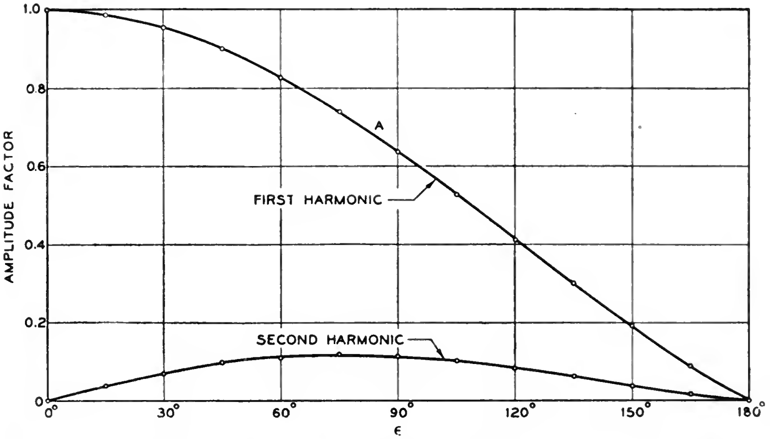


FIG. 7. Amplitudes of the first and second harmonics of the record when $\gamma = 2$.

When these functions are developed in a series of harmonics, the recorded wave is found to have the form

$$h = \left\{a - \frac{4af}{\pi\epsilon}\left(1 - \frac{\sin\epsilon}{\epsilon}\right)\right\}$$
$$+ A\ af\cos\omega t'$$
$$+ \left(\frac{8}{9\pi}\frac{1-\cos\epsilon}{\epsilon}\right)A\ af\cos 2\,\omega t' + etc.;\left[A = \frac{\sin\epsilon}{\epsilon}\right]$$

The factor, A, in the coefficient of the first harmonic is the same as was obtained for the case when gamma equals one. The coefficients of af in the amplitudes of the first and second harmonics are shown plotted against ϵ in Fig. 7. It is notable that the ratio of the amplitude of the second harmonic to that of the first is *independent* of the modulation. The ratio is a maximum when ϵ = 133 degrees (ap-

prox.). Ordinarily this corresponds to a frequency of the second harmonic beyond the upper limit of audibility. To consider a particular case, suppose that the width of the recording image is 0.001 inch, the speed of the film 18 inches per second, and suppose that frequencies higher than 10,000 cycles per second are not reproducible; the greatest ratio of the second harmonic to the first in which there is any interest then occurs at a frequency of 5000 cycles per second (of the first harmonic), which corresponds to $\epsilon = 50$ degrees, and the

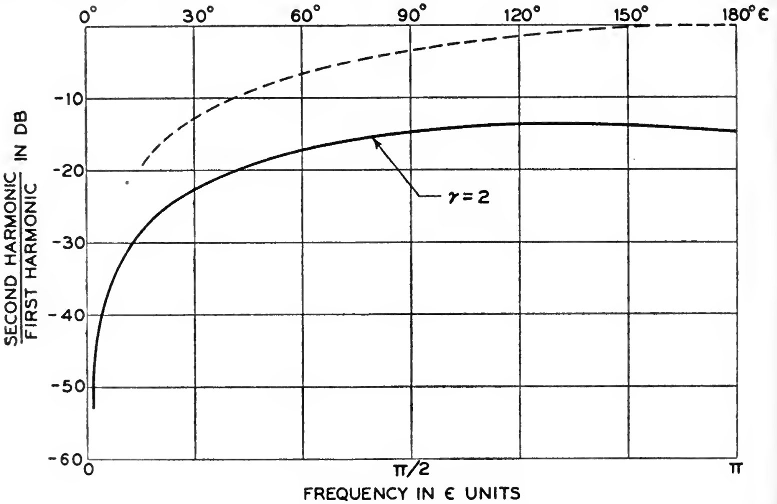


FIG. 8. Ratio of the power of the second harmonic to that of the first harmonic of the record when $\gamma = 2$, in decibels. The upper (dotted) curve is the limit of the distortion obtainable by reason of overexposure or by over- or underdevelopment.

ratio is then equal to 0.114. We have just seen that for $\gamma = 2$ the ratio of the amplitudes of these two harmonics is

$$\frac{8}{9\pi} \frac{1 - \cos \epsilon}{\epsilon}$$

which is a function of the frequency (through ϵ) and *independent* of the modulation. This ratio is plotted on a scale of decibels as a function of the frequency (ϵ) in Fig. 8.

EFFECT OF NON-UNIFORM INTENSITY IN THE IMAGE

As a step toward deducing the effect of image width in recording and reproducing it was supposed at first that the illumination of the

image is uniform. This assumption is not valid on account of the diffraction of light. The departure from uniformity is greater the narrower the image and the smaller the relative aperture of the lenses. Ordinarily the image would be nearly uniform over about one-half or two-thirds of its width if the lenses were free from aberration. But the aberrations present in good lenses of high relative aperture introduce still more non-uniformity.

It is, therefore, necessary to see how this unavoidable non-uniform intensity of the actual image affects the results that have been obtained upon the assumption of uniform illumination.

The calculation of the loss of amplitude in reproducing with an image of any given intensity distribution may be made by mechanical integration in the following manner:

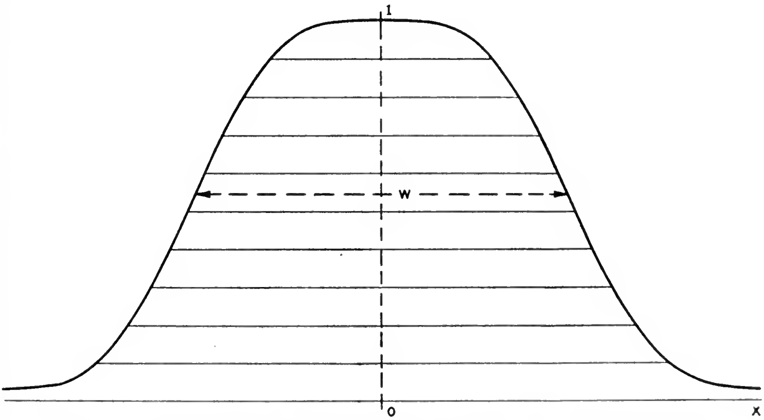


FIG. 9. Distribution of illumination in the image of a finite slit.

Let the curve of Fig. 9 represent the distribution of intensity across the reproducing image. It may be supposed that the given image is made up of m superposed uniform images of equal intensity, ΔI, and of various widths, $w = 2x$, as exhibited by the laminae of the figure. The attenuation factor is different for each of these elements, diminishing as the width increases.

The current in the photoelectric cell due to an elementary uniform image (Fig. 9) is

$$\Delta i_i = k[a + A_i \, afA' \cos \omega t]2x_i \, \Delta I$$

where k is a constant, $(a + afA' \cos \omega t)$ is the wave recorded, and

$2x$ is the width of the i^{th} elementary image. The symbols A, A' have the same signification as before. The total current in the cell is

$$i = ka\left[\sum_1^m 2x_i \Delta I + \left\{\sum_1^m A_i\, 2x_i\, \Delta I\right\} fA' \cos \omega t\right]$$

The amplitude attenuation factor for reproducing is therefore

$$F \equiv \frac{\sum_1^m A_i x_i}{\sum_1^m x_i}$$

In this expression for F, the number A_i is to be regarded as a function of $\epsilon \equiv \pi \dfrac{nw}{v}$, where w is variable, and the frequency, n, is fixed. Thus for *each* frequency, A_i will have a different set of values corresponding to the constant set of numbers x_i.

In recording by the variable width method with an image which gradually falls off in intensity at the sides and ends as all actual images do, the simple, exact method of calculation used in the case of reproducing cannot be employed. The assumption of linearity between transmission and exposure is violated over a relatively greater range than when the image is uniform. Aside from this, it is easy to see that the effect of the tapering of intensity at the tip of the recording image is to produce a kind of shading of the transmission of the edge of the record similar to that caused by developing to a gamma greater than one. This suggests that when the image is non-uniform the record will probably have less non-linear distortion if it is developed to a gamma a little less than one.

CONCLUSION

(1) Practically, freedom from non-linear distortion in positive prints made by the variable width method is obtained when the following sufficient conditions are satisfied:

(*a*) complete exposure in recording and printing corresponds to the upper extremity of the straight portion of the H & D curve;

(*b*) the image of the recording aperture is rectangular and uniformly illuminated;

(*c*) the transmission of the dense part of the record is negligible;

(*d*) the over-all gamma is equal to one.

(2) The attenuation due to the reproducing aperture is calculated and found to vary with the frequency in the same way as for recording.

(3) The existence of non-linear distortion for a gamma other than unity is demonstrated; and the distortion is calculated for the case $\Sigma = 2$. While the analysis is not carried out for cases other than $\gamma = 1$ and $\gamma = 2$, it is pointed out that Cook's results set a superior limit to the amount of non-linear distortion obtainable by over-exposure or by large departures from the condition, $\gamma = 1$.

(4) The effects produced by diffraction and by lens aberrations on the quality of the record and on the loss in reproducing are considered.

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[1] HARDY, A. C.: "The Rendering of Tone Values in the Photographic Recording of Sound," *Trans. Soc. Mot. Pict. Eng.* (1927), No. 31, p. 475.

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HIGH FREQUENCY RESPONSE FROM VARIABLE WIDTH RECORDS AS AFFECTED BY EXPOSURE AND DEVELOPMENT*

G. L. DIMMICK**

Summary.—The photographic treatment of variable width films is a subject of much interest to those who are concerned with the problem of obtaining the maximum high frequency response from a given type of film. An experimental study of the effect of photographic treatment upon the 6000-cycle output from Eastman positive film has been made. The results of this study show how the 6000-cycle output of a print varies with the density and gamma of the negative and the print. The variation in negative output with density and gamma is also shown. Under optimum printing conditions the output of a 6000-cycle contact print (made on the frame printer) is 92 per cent of that obtained from the best negative.

The photographic treatment of variable width sound films is a subject of much interest to those who are concerned with the problem of obtaining the maximum high frequency response from a given type of film. Some types of film have properties which make them inherently better for recording sound than others. For a given film there are optimum conditions of photographic treatment which result in the most effective utilization of its inherent qualities. The purpose of this paper is to present the results of an experimental study of the effect of photographic treatment upon the high frequency response obtained from Eastman positive film.

There are two ways in which a variable width record may be used. It may be placed in a reproducing machine and played, or it may be used as a negative from which to make prints. In the first case the usefulness of the record will depend upon its ability to modulate a narrow beam of light. Considering an ideal variable width record (one in which both the light and dark portions are uniformly dense), such as is shown in Fig. 1 (*a*), this modulation is proportional to the difference between the transmissions of the light and dark portions

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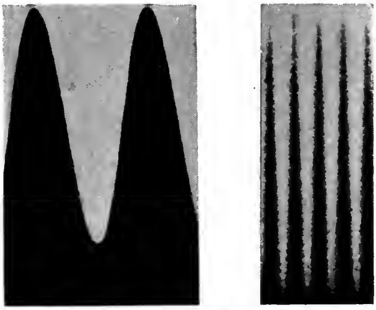
** RCA Victor Co., Inc., Camden, N. J.

of the sound track. If the record is used for printing, its value as a negative will depend upon the ratio of the transmissions of the light and dark portions of the sound track.

For the case of an ideal variable width record the best conditions of photographic treatment can readily be determined by calculation, if the H & D and fog density curves of the film are known. Such a calculation has been made by Mr. J. A. Maurer,[1] the results of which have been published in this JOURNAL.

The assumption of an ideal variable width record cannot be made when dealing with frequencies such that the wavelength on the film is comparable with the emulsion thickness and with the width of the recording beam. Fig. 1 (*b*) shows a 6000-cycle constant frequency



(*a*) (*b*)

FIG. 1. (a) 1000-Cycle negative; (*a*) 6000-cycle negative.

record made on Eastman positive film running at 90 feet per minute. The wavelength is 0.003 inch, the width of the recording beam is 0.0007 inch, and the emulsion thickness is approximately 0.0005 inch. An inspection of this record shows that the density in the exposed portion of the wave is not constant but gradually diminishes toward the peak. The supposedly clear portions between the peaks are not uniformly clear but gradually increase in density toward the bottom of the valleys. This filling in of the valleys and diminution of density toward the peaks results in a loss of output at high frequencies. The two principal causes for the loss of output at high frequencies are the lack of resolution of the film and the effect of the finite width of the recording light beam.

It is often supposed that the limit of resolution of a film is deter-

mined by the grain size, but this is obviously not the case, since the individual grains which make up the wave shown in Fig. 1 (*b*) are extremely small as compared with the size of the wave. Probably the most serious factor limiting the resolution of a film is irradiation of light within the emulsion. Light striking the white particles of the emulsion is scattered in all directions, resulting in the exposure of many particles outside the boundaries of the light beam.

The diagram of Fig. 2 (*a*) shows how the finite width of the recording light beam affects the distribution of exposure in the recorded wave. The two sine waves are traces of the points, v and u, respec-

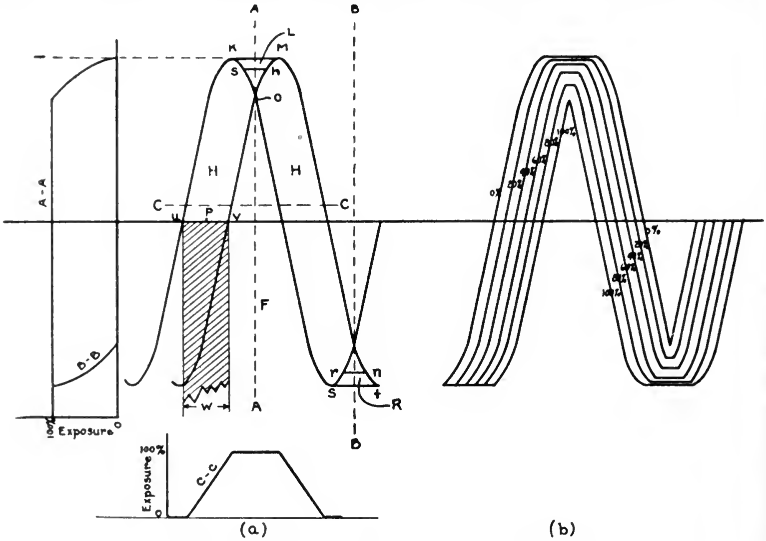


FIG. 2. Effect of slit width upon the distribution of exposure.

tively, on the entering and trailing edges of the beam. It is apparent that the entire area inclosed by the two curves is not uniformly exposed. Assuming a film to be traveling at a constant velocity past a light beam of uniform intensity, the exposure is proportional to the width of the beam. If a particle on the film does not traverse the entire width of the beam its exposure is proportional to the width of that portion of the beam actually traversed. Referring to Fig. 2 (*a*), all points in section F receive the maximum exposure which we will call E. A point p in section H receives an exposure equal to $\frac{up}{uv}E$. All points along a line gh in section L receive an exposure

equal to $\frac{km - gh}{km}E$. All points along a line rn in section R receive an exposure equal to $\frac{rn}{st}E$. The curve at the bottom of Fig. 2 (*a*) shows how the exposure varies along a line C–C taken through the center of the wave parallel to the direction of motion of the film. The curves to the left of Fig. 2 (*a*) show how the exposure varies along lines A–A and B–B taken through the peak and the valley of the wave, respectively.

Fig. 2 (*b*) shows the distribution of exposure by means of equal exposure contours. It is seen that the effect of the width of the recording light beam is to decrease the density at the peak of the wave and to increase the density in the valley. Both of these effects result in a loss of output and are quite apparent in the 6000–cycle recording shown in Fig. 1 (*b*).

A mathematical determination of the proper photographic treatment of variable width films for maximum high frequency response would be extremely difficult if not impossible. The experimental method, while quite laborious, has been chosen as the easier of the two. The two principal factors which may be varied in a photographic sound record are the density of the unmodulated part of the track and the gamma or contrast factor. Since it is usually desirable to play the print rather than the original negative, a complete study of the best photographic treatment would have to include all possible combinations of negative gamma, print gamma, negative density, and print density.

The amount of time required to make such a study depends, of course, upon the number of different values of density and gamma used, being approximately proportional to the fourth power of this number. It was felt that the density range could be adequately covered by six values and the gamma range by four values, making a total of 576 combinations of density and gamma for the negative and print. The output of the prints made from a 6000-cycle constant frequency negative was measured for each of the 576 combinations. The data thus obtained were plotted in the form of 96 curves, each showing the variation of output with print density for a given negative density and a given set of values for negative and print gamma.

The apparatus used in recording the negatives consists of an inclosed drum upon which the film is mounted, a constant-speed

motor for driving the drum, an automatic shutter which opens for a single revolution, and a recording optical system. The optical system is similar to those used in commercial recording. The galvanometer is one of the large mirror type, which permits the reduction of stray light to a minimum. The width of the recording light beam at the film is 0.0007 inch.

Four strips of film were placed on the drum in succession. Upon each of these films were recorded six constant amplitude 6000-cycle tracks. Each of the tracks was given a different exposure, the exposures being predetermined to give the desired range of densities. The films were then developed in Eastman *D*-16 developer at 65°F., the development times being 4, 6, 8, and 10 minutes. The resulting values of gamma were 1.4, 1.8, 2.0, and 2.18. The densities were measured in the unmodulated part of the track by means of a Capstaff densitometer.

From each of the four negatives, four sets of contact prints were made with a printing frame, each set consisting of 6 prints having different exposures. The four sets of prints obtained from each negative were developed 4, 6, 8, and 10 minutes. When completed, there were 576 prints representing an equal number of combinations of density and gamma.

The outputs of the prints were measured on a static analyzer consisting of a carriage upon which the film was mounted, a micrometer screw for moving the carriage, a reproducing optical system, a photoelectric cell, and a very sensitive galvanometer. The film was moved very slowly past the light beam, and the variation of current through the photoelectric cell was indicated by the galvanometer. The difference between the maximum and minimum readings of the galvanometer, as a recorded wave moved past the light beam, was taken as the output of the wave.

The average output obtained from five waves along a track was taken as the output of the track, and was expressed in centimeters (galvanometer deflection). The value of this unit is of little importance. The sensitivity of the measuring equipment was checked between successive measurements, and was held constant throughout the complete test. The focus and slit alignment were also carefully checked before each measurement. The width of the reproducing light beam was 0.0007 inch.

The curves shown in Figs. 3 to 6, inclusive, give an interesting picture of what happens to the output of a 6000-cycle record when the

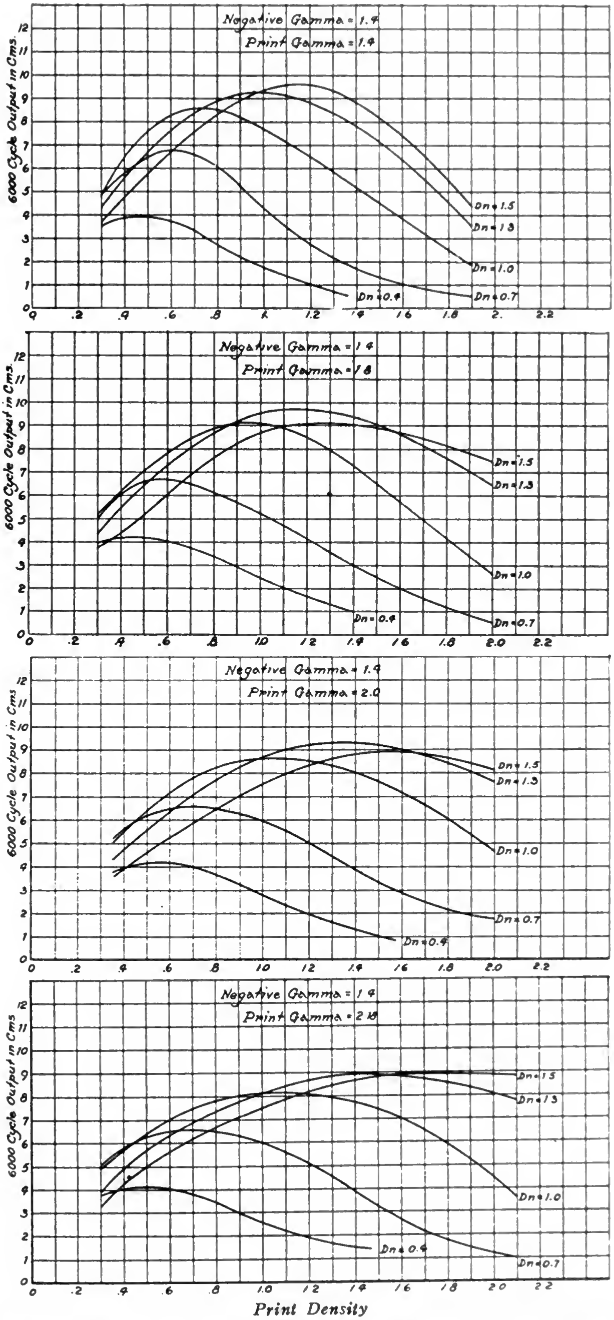


FIG. 3. Variation of output with print density for several negative densities.

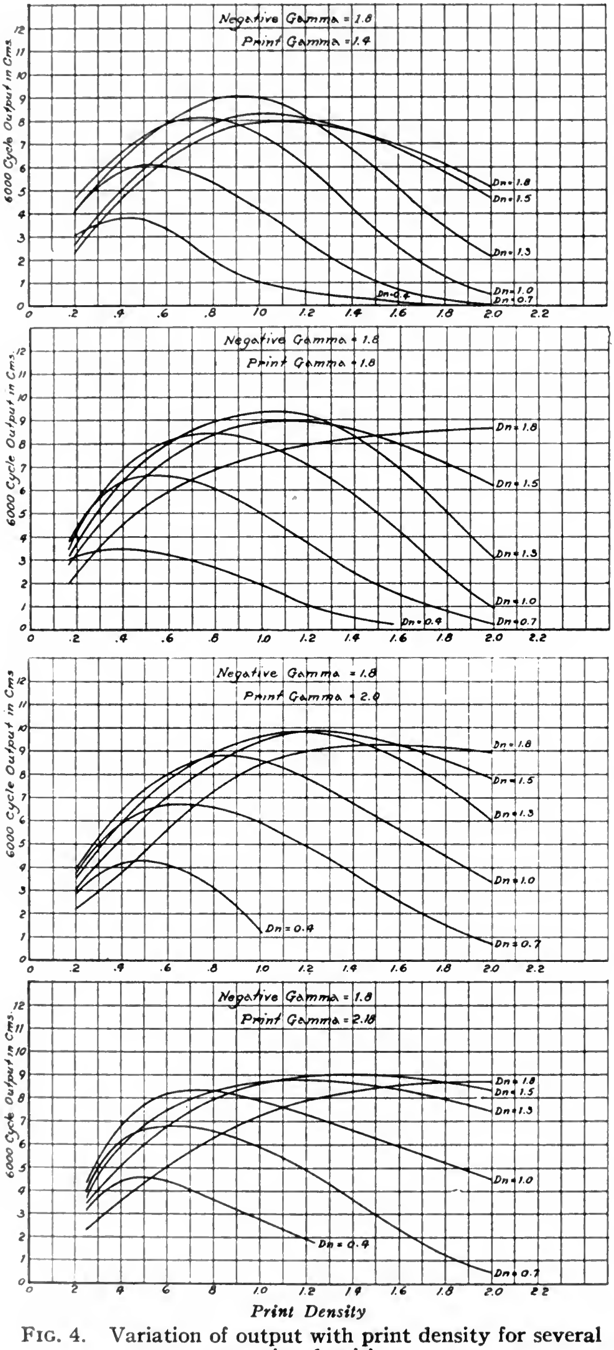


FIG. 4. Variation of output with print density for several negative densities.

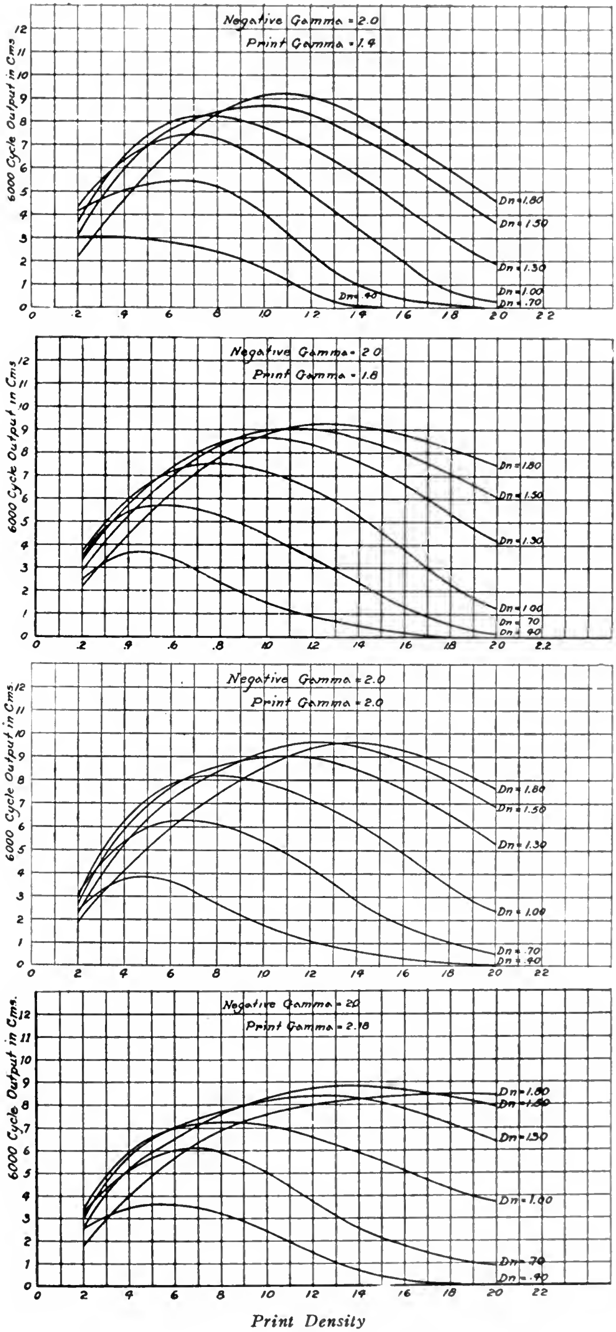


FIG. 5. Variation of output with print density for several negative densities.

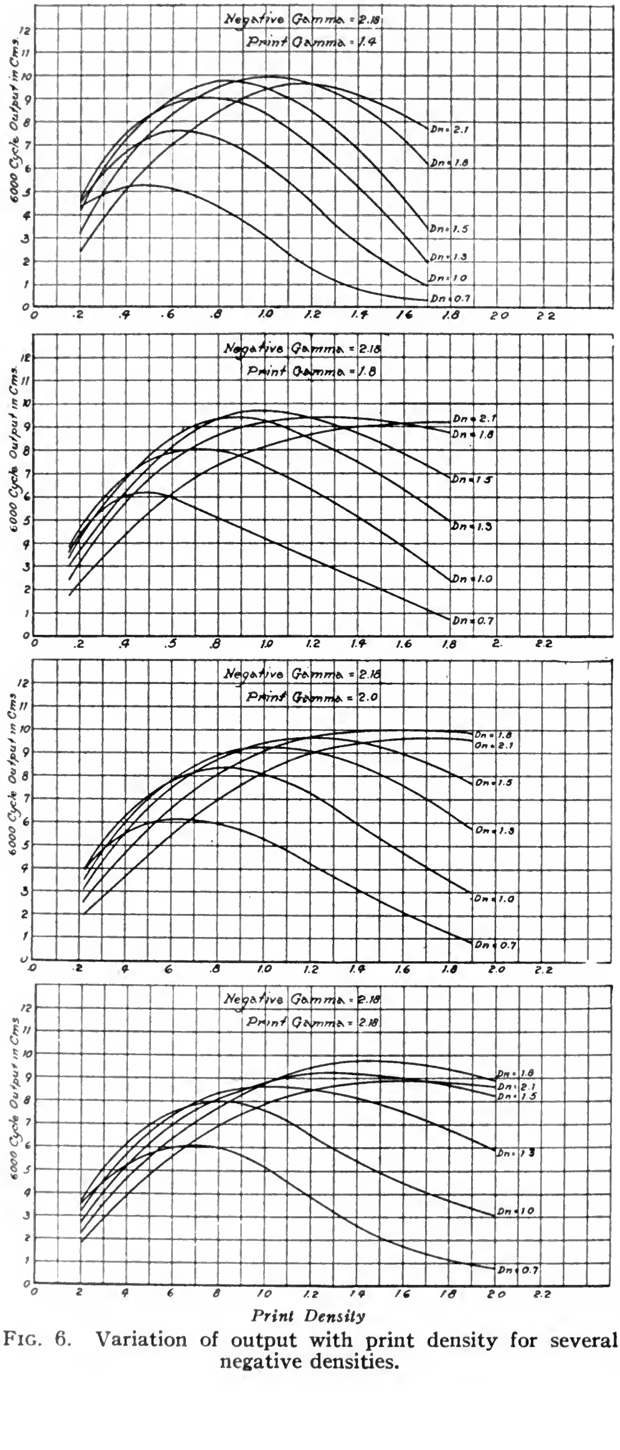


FIG. 6. Variation of output with print density for several negative densities.

photographic treatment is varied. The ordinates of these curves are proportional to the absolute output of the 6000-cycle prints. It should be understood, of course, that the low frequency output also varies with photographic treatment. The curves show the combined effect of two factors, one of which is present in both low and high frequencies while the other is present only in high frequencies. A complete study of the relation between these two factors at several frequencies should be very interesting and useful. Such a study will probably be presented in a later paper.

For any conditions of constant gamma of the negative and the print and constant density of the negative, the output increases with print density, reaches a maximum value and then decreases with further increase in print density. Both the print density at which maximum output occurs and the value of the maximum output are dependent upon the negative density and the gamma conditions for both negative and print. The peaks of the curves move upward and to the right as the negative density increases until a maximum is reached, and for still higher negative densities the peaks continue to shift to higher print densities but to lower output.

The effect of increasing the print gamma is to broaden the curves, thus making the output less critical to changes in print density. The effect of increasing the negative gamma is to broaden the curves slightly and to increase the general level of the output. One very definite conclusion borne out by the whole set of curves is that the negative density should be greater than the print density. This difference in density is greater for low values of print gamma combined with high values of negative gamma.

Of the 576 prints that were measured, the maximum output was obtained from the one which had a gamma of 2.0, a density of 1.6, and which was printed from a negative having a gamma of 2.18 and a density of 1.8. Referring to Fig. 5 it will be seen that the curve for $D_n = 1.8$ is very broad, the output being practically independent of print density within the range from 1.4 to 1.8. This condition of flatness is a very desirable one and is obtained by using high values of gamma together with a high negative density. As shown in the curves there are many conditions of photographic treatment which give nearly as much output as the one referred to above.

Fig. 7 shows how the output of the original negatives varies with density and gamma. When the negative is played directly the maximum 6000-cycle output is obtained when the density is 1.1 and the

gamma 2.0. Because of the ground noise resulting from such a low density, it would probably be desirable to increase the density to 1.3 or 1.4 at the expense of a few per cent reduction in high frequency response.

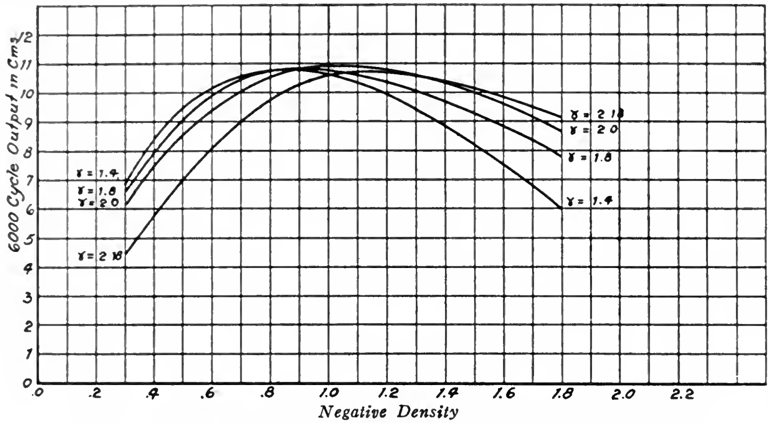
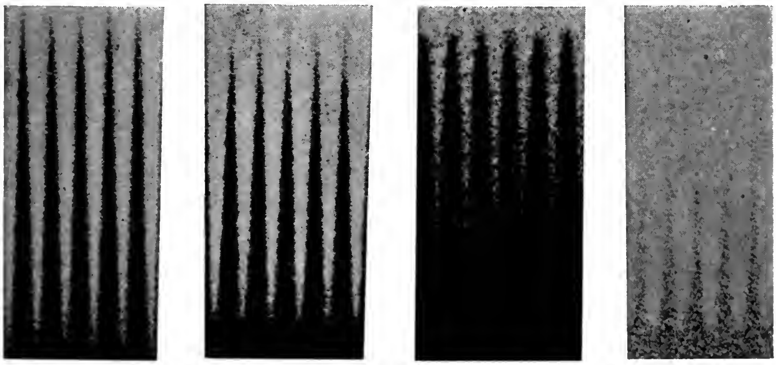


FIG. 7. Variation of negative output with density and gamma.

It is very interesting to note that the output of the best print is 92 per cent of that obtained from the best negative. The best print was not made from the negative which gave the most output. The



(a) (b) (c) (d)

FIG. 8. 6000-Cycle negative and three prints.

best print gave about 9 per cent more output than the negative from which it was printed.

Fig. 8 shows a 6000-cycle negative and 3 prints. The first print

(*b*) was made under the optimum printing conditions. Fig. 8 (*c*) is an example of a heavy print made from a light negative. Fig. 8 (*d*) is an example of a light print made from a heavy negative. Both of these figures represent very extreme conditions of photographic treatment. The amplitude of the light print appears to be considerably less than the amplitude of the negative from which it was printed. This is because the valleys of the heavy negative were so badly fogged that the exposure in the peaks of the print fell below the toe of the H & D curve.

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THE PROCESSING OF VARIABLE WIDTH SOUND* RECORDS IN THE FILM LABORATORY

W. P. BIELICKE**

Summary.—*Methods of using sensitometric data in processing variable width sound records in film laboratories are described and the great importance of these records as contributing to a successful product is stressed. These data include density exposure curves, time gamma curves, etc. The method of applying the data for determining the time of development is described. The relation between the required exposing lamp current and the gamma is discussed.*

The impression prevails that the variable width system of recording permits a very wide latitude in the photographic treatment without sacrifice of quality in the sound reproduced. However, variations in exposure and in the time of development of negatives and prints do affect the quality of sound. These sacrifices in quality are readily determined as a loss in frequency response or a decline of volume. The purpose of this paper is to describe a practical method of preventing these variations.

Two important considerations in processing variable width sound records are resolving power and opaqueness. Resolving power can be translated into high frequencies, as, qualitatively speaking, resolving power is the ability to render fine detail. Opaqueness of the sound track can be translated into volume, since the electric current emitted by a photoelectric cell is practically a linear function of the amount of light which reaches it. Consequently, the greatest volume response is obtained when there is complete transmission of light in the transparent half of a sound wave and complete extinction of light in the opaque half. It is generally agreed that for all practical purposes the best resolution is obtained at a gamma of 1.65 to 2.10, and a density of 1.2 to 1.6, when using a film stock on which good picture prints can be made. A resolution of 60 lines per millimeter

* Presented in the Symposium on Laboratory Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** West Coast Engineering Department, RCA Photophone, Inc., Hollywood, Calif.

corresponds to a frequency of 27,000 cycles per second. Densities of 1.2 to 1.6 give a substantial opaqueness without undue loss of resolution, as the respective transmission is from 6.31 to 2.50.

When using the photographic values of gamma, density, *etc.*, we are entering the field of sensitometry. Density is the common logarithm of opacity or the amount of the substance in a photographic emulsion which prevents light from passing through. Gamma may be explained as the degree of contrast to which film has been developed. It is measured as the slope of the straight line portion of the H & D curve or the tangent of the angle formed by the intercept of the straight line with the logarithm of exposure axis. Gamma is dependent principally upon the time of development. The H & D curve is obtained by plotting the densities as ordinates against the logarithms of exposures producing them as abscissas. The H & D curve becomes the guide and tool of the film laboratory worker. Developing time and exposure are both determined by the H & D curve. The conditions and sensitometric characteristics of the developing process can be analyzed by adapting the single H & D curve to time-gamma curves, and augmenting the data of time-gamma curves by those of of time-density curves. In the case of the former, the various gamma values obtained in a series of different developing speeds are plotted as ordinates and the different developing speeds as abscissas. For the latter, different densities obtained in a series of various developing speeds, but for a constant exposure, are plotted against the various developing speeds.

As we have noted, gammas of 1.65 to 2.10 are the most useful. Obviously then, we must use a developing solution which effectively produces these gammas. A solution producing low contrast, such as may be used for picture negative, the time-gamma curve of which is extremely flat and does not rise above a gamma of 1.00, would not be suitable, nor would a solution whose time-gamma curve is extremely steep and reaches values of gamma-infinity be suitable. Gamma-infinity is the highest gamma obtainable, almost reaching a value of 3.00. Judging by means of these time-gamma curves we choose a happy medium, so that at normal developing speed we obtain the desired gamma. The increase in gamma with increase in time is also noted, so that the final result can be predetermined, even though variables acting before the film enters the laboratory cause a change in developing speed. The time-gamma curve finally chosen will probably show small but sufficient increase in gamma with increase

in time, so that over a medium range of developing time the gammas of the sound film will vary from 1.65 to 2.10. Of necessity, the curve is fairly steep, maximum contrast being reached in slightly less time than in common solutions used for pictures only. Continued development will increase the density but not the gamma.

From this point on, density must be considered. As only the outline of the sound wave is reproduced, there is no need to consider linearity in the photographic tone scale. To control the density and to ascertain the correct developing time, the laboratory man must determine the increase or decrease in time necessary to produce a constant change in density. The procedure is to take several unmodulated variable width sound tracks, each made with a different but a constant lamp current, and to break these tracks into many strips and develop these strips for various developing times and under different developing conditions. The various developing times should vary in equal steps from the longest to the shortest, and the different developing conditions should include development in a fresh, unused solution, and in an old, used solution. The resulting densities are plotted against time, and the linear relationship between time and density is noted. All work and calculations must be within the limits of this straight line. The average of these various curves must be used, and the change in time necessary to obtain a change in density of 0.10 determined. There are two factors which, from this point on, determine the developing time for the sound negative: (*a*) an exposure or developer test made by the recorder with the same lamp current used for the negative, and (*b*) a constant developing time at which these exposure tests are run. That developing time for the exposure tests is preferred which results in the ideal gamma and density mentioned before. How the correct lamp current is obtained will be described later. Now, if a change in time of 15 seconds produces a density change of 0.10, and the exposure test reads 1.30 density at 3:30 minutes, then the sound negative must be developed 3:45 minutes to give a standard density on the negative of 1.40. The data mentioned in the foregoing paragraph may be summarized in the following equation:

$$\frac{\Delta D}{D'} \cdot T' = \pm \Delta T$$

in which ΔD is the increment of density or the difference between the density of the exposure test and the required density; D' is the density change for a time change of T'; and $\pm \Delta T$ is the increment of

time or the amount the developing time has to be increased above or decreased below the time of the exposure test to obtain the required sound negative density.

This standardization of the routine of processing sound films will be of no avail unless the recordist uses the proper lamp current for exposing the film. This lamp current is easily determined. For example, let us suppose that at 3:30 minutes a gamma of 1.80 is obtained and the lamp on the recording machine is rated at 6.0 amperes. Next, suppose there is developed a length of film which has been exposed to various lamp currents in steps of 0.10 from 5.0 to 6.2 amperes for 3:30 minutes to a gamma of 1.80. The resulting densities are plotted against the various lamp currents and the correct lamp current is easily read from this density *vs.* lamp current curve. And last, but not least, the chemical fog on all film must be carefully noted, as excessive fog is very objectionable. This chemical fog should not rise above a normal of 0.05 for positive stock.

The routine and method of processing sound films described in this article cannot be dogmatically applied to all processing conditions. As the processing conditions vary, so must the routine vary. For instance, a developing machine with a greater range of time than a second machine would certainly not require a developing solution, the sensitometric conditions of which are equal to the characteristics of the solution used in the second machine with a lesser range of time. But the principles outlined can easily be adapted in their applications to different conditions and the laboratory man must use judgment in applying them.

DISCUSSION

MR. MACINERNY: Graininess and dirt specks do not affect variable density and variable width records in the same way when noise reduction is considered. Graininess data compiled for photographic purposes are only approximately significant when applied to sound recording. A distinction should be drawn between "visual" and what might be termed "photoelectric cell" graininess. That the two are different in nature can be emphasized for the purpose of illustration by saying that it is conceivable that grains of simple symmetrical form could be so arranged as to appear grainy to the eye and not to the cell.

Visual graininess for any given emulsion is maximum around fifty per cent transmission; that is, when the black and white areas are about equal in number. Photoelectric cell graininess is maximum when, irrespective of track opacity, and provided that the flux on the cell is kept constant, the light fluctuations on the cell brought about by integrated action of all the grains coming under the scanning light are most marked. That this maximum should take place around fifty per cent transmission, as in the case of visual graininess, is not self-evident.

When talking of the effect of grain, dirt, and more generally, of light obstacles on the cell, the geometry of the scanning light should be specified. It is reasonable to assume that for constant flux and width, a scanning beam one-tenth of a mil thick should give more noise than another one mil thick, because the effect of the light obstacle on the cell is a function not only of its absolute size, but of its relative size with respect to the integrating area and its contrast with respect to the carrier gray.

In variable density recording the flux unnecessary for modulation is cut out by varying the opacity of the track, thus keeping the size effect of a light obstacle unchanged and decreasing its contrast effect. In variable width recording the flux not required for modulation is suppressed by cutting down the size of the integrating area. A light obstacle in this case affects the photoelectric cell by both its contrast, which remains unchanged, and its size, which becomes proportionally greater. This causes me to incline toward the belief that noise reduction in variable density recording holds perhaps greater promise than in variable width recording.

MR. TOWNSEND: Inasmuch as the processing of film is directly connected with the amount of noise produced, it is a very important problem that must be solved sooner or later if we are going to put high quality release prints into the theater. You will recall that the range over which modulation is possible in variable density track is definitely fixed, and in order that a fair comparison may be made between the relative amounts of noise there should be a starting point, and that starting point should be 100 per cent modulation; that is, in the variable density system, the limits within which it is possible to open and close the valves, and in the variable width system the range from zero modulation to full track. In the variable width system the modulation is represented as the full track for 100 per cent modulation, where the peak of the wave just reaches the extreme limits of the track. Under these conditions we find that in projection the relative outputs from fully modulated variable density tracks and fully modulated variable width tracks are considerably different, the greater output being obtained from the variable width track. In projection we find, therefore, that for the same percentage of modulation, it is possible in theaters to operate with a lower gain in order to obtain a given output level at the speaker.

NEW FILTERS FOR EXTERIOR PHOTOGRAPHY WITH SUPERSENSITIVE FILM*

EMERY HUSE AND GORDON A. CHAMBERS**

Summary.—*The use of new filters known as the "3N5" and "5N5" in making exposure shots with supersensitive film is described. The need for such filters is shown to be made necessary by the nature of the color sensitivity of the supersensitive film. The effect of these filters on the required exposure time, lens aperture, or illumination incident upon the object being photographed is discussed in relation to the filter factors of the new filters. The paper concludes by outlining a simple method of applying the numerical value of the filter factors to particular cases.*

It is often desirable in photography to alter physically the spectral quality of the light by which a picture is to be made. This alteration of quality can be accomplished readily by light filters. A light filter in photographic terminology, is usually a piece of dyed gelatin having definite selective absorption for light.

Photographic literature contains a great deal of information relative to filters.[1] It is not the purpose of this paper to enter into a discussion of the theoretical aspects of light filtration. It is intended as an announcement of new filter combinations which are now available and which were designed specifically for use with the new Eastman supersensitive panchromatic negative film for exterior photography.

The filters which we are about to discuss are known as the "3N5" and the "5N5" filters. We must consider, of course, in any filter work the sensitivity of the photographic emulsion with which the filters are to be used. In this instance we are concerned with the sensitivity of the supersensitive film. Details relative to the Eastman supersensitive film were outlined in detail in a paper by the authors presented at the last meeting of this Society in Hollywood.[2] That a clearer picture might be had of the sensitivity of this film as compared with the sensitivity of the film it more or less replaced, namely, regular Type Two panchromatic film, we show in Fig. 1

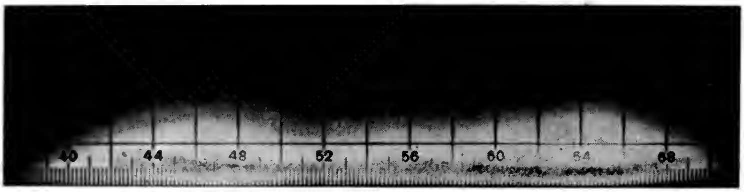
* Presented at the Fall, 1931, Meeting at Swampscott, Mass.

** West Coast Division, Motion Picture Film Department, Eastman Kodak Co.

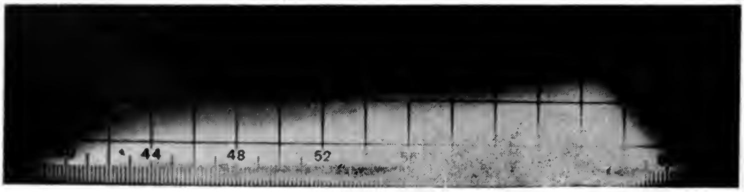
spectrograms of the two films just mentioned. It will be observed that the supersensitive film shows greater green and red sensitivity when exposed to the same source, in this instance daylight, than does the Type Two.

Figs. 2 and 3 show the spectrophotometric curves of the two filters in question. These filters are combinations of certain yellow filter dyes with a definite density of a neutral gray filter. The 3N5 is a combination of the Wratten Aero 1 plus a neutral density filter of approximately 0.50 (T. 32 per cent). The 5N5 filter is a combination of the Wratten Aero 2 plus a neutral density filter of 0.50.

Wedge Spectrograms



Eastman Type Two



Eastman Supersensitive

FIG. 1. Wedge spectrograms of Eastman Type Two and Supersensitive films.

We should at this point make some mention of the use of neutral filters in practical cinematography. There has been very little written on the use of neutral filters for this practical type of work. One of the best articles on the subject is that by Joseph Dubray in the September, 1928, issue of the *American Cinematographer*. Mr. Dubray makes the following statements: "The exigencies of modern cinematography have brought about the use of a neutral gray light filter which serves to reduce the effect of the incident light upon the film without having recourse to either the reduction of the lens aperture or the reduction of the angular opening of the camera shutter. In

other words, by the use of these filters the exposure can be regulated at will by the cinematographer while maintaining the desired depth of

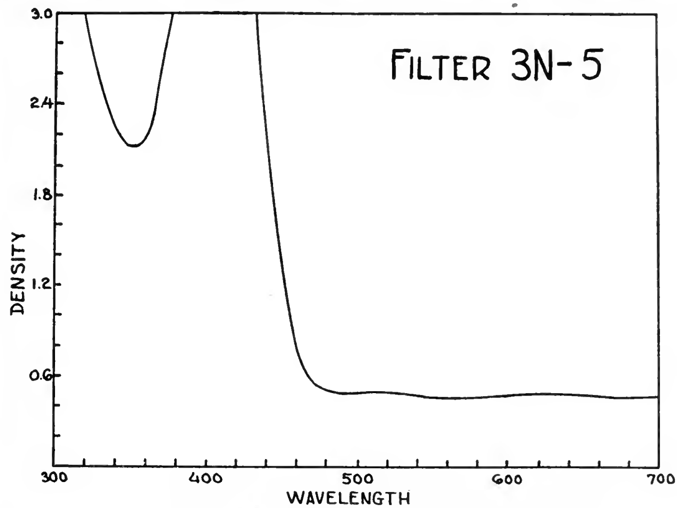


FIG. 2. Density *vs.* wavelength curve for 3N-5 filter.

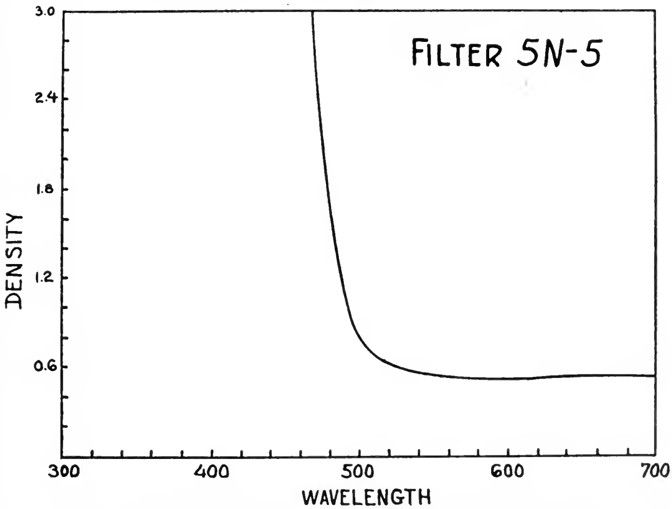


FIG. 3.—Density *vs.* wavelength curve for 5N-5 filter.

focus and color rendition." This summary by Mr. Dubray is, we believe, sufficient at the moment.

As was previously stated, the two filters referred to, namely, the

3N5 and the 5N5, were designed for use in exterior photography. There is nothing new about the Aero filters as such. The point being featured at this time is the combination of these filters with the neutral dyes. In the making of exterior motion picture scenes the cameraman rarely stops down the lens to the point where the depth of focus is approaching infinity. Many exterior scenes are shown with apertures as wide as $f/3.5$. Naturally, with an emulsion whose speed is as high as that of the Supersensitive, and as a matter of fact, even with lower speed emulsions, such as Type Two, the cameraman felt it necessary to cut down the exposure on exterior shots without stopping down the lens. The simplest way to accomplish this is to make use of neutral density filters. As these are obtainable in various degrees of density (and, naturally, transmission) it is possible to obtain neutral density filters which will allow the cameraman to make exterior shots at whatever aperture he desires, which is usually fairly wide open, and, in the case of Type Two, to make them with a neutral density filter approximating 0.25 in density (T. 56 per cent). With the increasing use of Supersensitive film cameramen found that this neutral density was not sufficient, and that it was necessary to cut down the exposure still more. Attempts to promote stopping down lenses were unsuccessful in many cases so that the only alternative was to use neutral density filters of lower transmissions (increased density) or to cut the angular opening of the shutter. This latter feature has several undesirable aspects, and therefore is not adopted. Inasmuch as the speed of the Supersensitive film to daylight is approximately twice that of Type Two, it is very simple to adopt neutral filters whose transmissions are half those used for Type Two.

The sensitivity of the Supersensitive film when compared to Type Two is such that in effect the Supersensitive film has approximately a K2 filter correction within itself. It will be observed from the spectra of these two emulsions that the basic difference in the spectral characteristics between Supersensitive and Type Two film is the increased proportion of red sensitivity of the Supersensitive. Because of this fact, primarily the K series of filters up to and including the K2 have relatively little effect on Supersensitive film, either from the standpoint of exposure or of color correction. Experience has shown that the K3 and G filters normally produce over-corrected results on Type Two, but that this is not true in the case of Supersensitive film. With the latter film it is desirable to have filter corrections of a lesser degree

than the G or K3 filters give. To accomplish this we have tested several filters and it was found that the Aero filters produce these lesser correction effects quite satisfactorily and can be used as intermediates between the clear and the K3 or G corrections.

These Aero filters upon tests by various cameramen have proved to be extremely satisfactory, but as was the case for either unfiltered or filtered shots, the neutral density filters were also used. It was because of the seeming necessity of using two filters that the Aero 1 and 2 filters were made, each containing the neutral gray dyes so that both the correction and the decrease in exposure could be accomplished with the use of a single filter. A study of these filters to determine their exposure factors shows that for Type Two the 3N5 filter has a filter factor of 5, while the 5N5 has a filter factor of 8. For Supersensitive film the 3N5 has a filter factor of 4, while the 5N5 has a filter factor of 5. It would be well to state at this point what a filter factor is. When a filter which absorbs some of the radiation to which the photographic material is sensitive is placed over the lens of the camera, it is evident that an increase either in exposure time, in the lens aperture, or in the illumination incident upon the object must be made in order to obtain the same exposure on the negative as when no filter is used. The magnitude of the filter factor depends upon the conditions under which the filter is used, and its determination involves a knowledge of the spectral sensitivity of the photographic material, the spectral distribution of energy in the radiation which illuminates the object, and the spectral absorption of all components of the optical system between the objects and the photographic material. The factors quoted previously take into consideration the sensitivity of the emulsion, the spectral distribution of daylight, and an average camera lens.

The method of applying the filter factors given above is very simple. Let us consider the case of the 3N5 filter and Supersensitive film. The factor given is 4. This means that it is necessary to increase the exposure normally given without the filter four times. From the standpoint of lens stop, if the unfiltered shot were made at an aperture of $f/4$, then the aperture should be increased to $f/2$ to take care of the filter factor. By a simple computation it can be seen readily that the amount of light passing through the stop $f/2$ is four times that passing through $f/4$. If the factor is 5, or any other figure, the aperture to accommodate the filter factor can be computed by the following simple formula:

$$\frac{f_1^2}{F.F.} = f_2^2$$

where f_1^2 = square of stop with no filter

f_2^2 = square of stop with filter

$F.F.$ = filter factor

For example, if, as stated above, the unfiltered shot were made at $f/4$ then $f_1^2 = 16$; if the filter factor were 4, then $F.F. = 4$; the stop (f_2^2) at which to make the filtered show is therefore:

$$\frac{f_1^2}{F.F.} = f_2^2 \text{ or } \frac{16}{4} = f_2^2$$

$$f_2^2 = 4$$

$$f_2 = 2$$

If the filter factor is 5, as would be the case when using the 5N5 filter, then by the above reasoning

$$\frac{16}{5} = f_2^2 \text{ of } f_2^2 = 3.2 \text{ and } f_2 = 1.8$$

Since these filters have been available only recently, no examples of their use may be cited. However, several cameramen are using these at the present time in current productions in Hollywood.

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[1] JONES, L. A.: "Light Filters, Their Characteristics and Applications in Photography," *Trans. Soc. Mot. Pict. Eng.*, **XI** (1927), No. 30 p. 135.

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MOTION PICTURE SETS*

HANS DREIER**

Summary.—*The function of motion picture sets is to create the proper atmosphere for the action and to establish in the viewer's mind a mood which is characteristic of the scene. Sets are constructed of light-weight materials which are made to appear solid and real by means of technical processes. The technic of using miniatures has been very highly developed and the processes can be made to provide perfect photographic illusions of great height and depth. The paper briefly describes the manner of using these miniatures.*

Designing a motion picture set is illustrating a story. The author of a novel describes, by means of words, the environment in which his characters act, in order to establish in the reader a mood characteristic of the scene of action. By this means he brings to the reader the proper atmosphere for the story.

This is likewise the function of motion picture sets. But while the writer has the world at his disposal and is limited only by his imagination, the designer of motion picture sets has to reckon with time, space photographing, sound recording, and commercial economy.

Reasons of practicability demand that motion picture sets be constructed of light-weight materials, which are made to appear solid and real by means of technical processes. To the eye, and more so to the camera, flimsy structures on the sets appear to be real rooms or buildings, *etc.*, of any desired elegance, dilapidation, or age. They are first planned and constructed in the form of sketches or models, in order to be sure to obtain the desired appearance and to create the proper mood when finally presented on the screen to the audience in the theater. These are the ultimate objectives to which everything in the conception and construction must contribute.

The materials of construction vary according to the effects desired. Flats of standard sizes are used for sets that represent rooms or

* Presented in the Symposium on Studio Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** Paramount Publix Corp., Hollywood, Calif.

buildings having finished surfaces. They are covered with veneer or, as acoustical requirements demand, with a soft composition board that prevents reverberation. When the surfaces are to appear as if made of brick, stone, or rock, casts of the real materials are made, and the reproductions are applied to the set. Plaster-coated wallboard and wood is used frequently for panels. The painting, which is of the greatest importance in producing the final character of the set, provides the finishing touch.

After the set has been conceived according to the purpose of the story and the intended mood, it is laid out according to the camera angles and the action which is to take place in it. The lens of the camera determines the horizontal and vertical dimensions of the set, and angles made of celluloid are used to fix these dimensions for all camera line-ups necessary to cover the action. When such points are settled, the designer begins work on the drawings, which are very much like those drawn by architects. Places for lights necessary to illuminate the set for photographing it must be provided, and, in consideration of the process of recording the sound, acoustic difficulties must be avoided. Finally, the proper furniture and properties are located, and the set is ready for use.

Time and space are of great importance in constructing sets, and are very vital economic items to be considered. For this reason a great number of photographic and scenic "tricks" have been developed. These may be grouped under two main headings: (*a*) the miniature processes, and (*b*) the processes employing transparencies. The latter is a photographic process for providing moving backgrounds. The actors are later superimposed on the background by a chemical process. This method avoids the necessity of constructing a large set. The miniature, however, is designed and constructed.

If a given part of a set is duplicated on a smaller scale and the replica is placed between the camera lens and the original set, preserving the original lines of sight emanating from the camera, the photograph of the portion in miniature will coincide exactly with that of the original set, and it will not be necessary to use the large set at all. This results from the fact that two-dimensional photography does not register the physical distance between the actual set and the part made in miniature. Fig. 1 illustrates the principle.

In order to carry focus, the miniature in the foreground must be placed at a certain distance from the camera lens. This distance determines the scale to be employed. Theoretically, an indefinite

number of scales are possible, but economic requirements make it necessary to choose a scale which will bring the focal plane as close to the camera as possible.

The miniature may be an actual construction; it may be simply a miniature scene painted on glass; or it may involve a combination of both processes. The technic of using miniatures in this manner, the construction, matching of lights and shadows and of distances, is highly developed, and the process can be made to provide perfect illusions of great depth and height.

The designer, when illustrating the background of a story, must explain his ideas by means of drawings in which he represents the de-

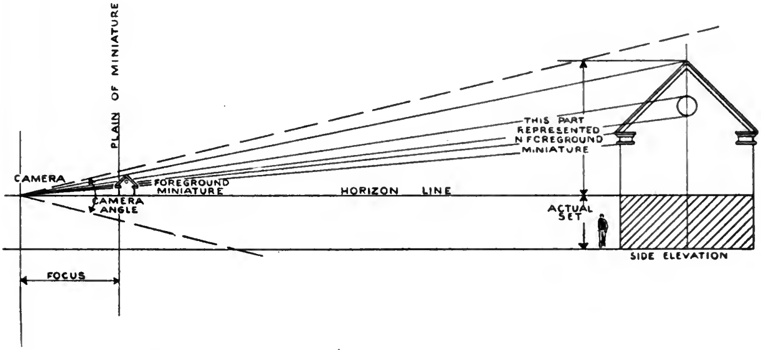

FIG. 1. Illustrating the principle of replacing the background by a miniature replica.

sired mood by indicating the apparent heights and the camera angle, balancing the proportions, lights, and shadows in the desired manner. But a sketch shows only one angle; the rest must be explained by a floor plan. It is often difficult for those unfamiliar with the process to obtain a clear idea of the final appearance of the set from all the angles at which the action is to be viewed. A model does not easily influence a mood or create an atmosphere because the light effects and the miniature furniture are not convincing, and the small scale of the set gives one the feeling of looking at a doll-house. The sketch always provides the best approach to an appreciation of the set as an illustrating background, while the model is indispensable where complicated ground plans, combinations of several sets, several floor levels, and action based upon these are required.

OPERATING PROBLEMS OF RECORDING EQUIPMENT*

LORIN D. GRIGNON**

Summary.—The organization of a sound department is treated briefly. Equipment requirements such as standardization, simplicity of circuits, and special testing are discussed. To provide a general idea of the work necessary to maintain sound recording equipment, transmission and electrical maintenance are discussed, with comments based on past experience. General statements regarding records and reports showing their use as valuable tools in this work are included. The latter part of the paper deals with a large studio installation, indicating how the methods outlined are applied. Photographs and a few short narratives of actual problems that have occurred are used for illustration.

This paper may be divided into two parts, the first dealing with some general features of the problems encountered, including design, operating, and supervisory principles, with a few examples; the second part dealing with the application of these principles by indicating some actual problems and their solution.

The first problem of any department is that of organizing the necessary personnel. In general, good business practice applies. It is very easy when grouping for organization to divide the responsibility for certain equipment, and this should carefully be avoided if a truly efficient group is desired. At the present time there are two types of organizations in the recording plants, one of which is particularly applicable to unit equipment, and the other to centralized systems. Where all the recording equipment is located at the scene of action one man for every particular duty is assigned to a production unit. These men are grouped under administrative heads as to the type of work which they perform. This type of organization requires a group of specialists who are available for difficult adjustments or maintenance problems.

The other type of organization is a combination grouping, in which a few men are assigned to the production unit, together with others

* Presented in the Symposium on Sound Recording, at the Spring, 1931, Meeting at Hollywood, Calif.

** Paramount Publix Corp., Hollywood, Calif.

who handle a particular duty for all the companies. The men who are not directly assigned to a production may be worked in shifts on a regular day schedule, thereby providing better working conditions.

The requirements for equipment are simple but not easy to obtain. Any design should be durable mechanically and electrically, particularly location equipment. It must be easy to operate, and by this we mean that it should have the smallest number of adjustments consistent with good quality recording and proper maintenance. Circuits must be as simple as it is possible to make them, consistent with continued improvement in the art. Simplicity tends to reduce the troubles and permits the operators to keep the circuits more clearly in mind, reducing the necessity of continually finding the proper drawing whenever working on the equipment.

Standardization is probably the most important equipment requirement. It becomes a great problem to operate a large installation intelligently when the same job is being done with various different circuit arrangements or different types of amplifiers. The lack of standardization means that each man must know intimately each circuit, its characteristics, how to set it up for every job, and how to locate trouble quickly. Such knowledge cannot be gained easily; it requires time and experience to attain facility. In general, individual pieces of equipment as supplied to the studios are fairly well standardized, but the installation of such equipment or auxiliary facilities should be closely watched.

Further equipment requirements can be met by simply good engineering practice, such as providing ample battery capacity in a well-ventilated location, centralizing the power equipment to keep brush dust from getting into delicate equipment, and isolating the high voltage power. The motor system used for recording must, of necessity, have stable speed characteristics, and should be capable of attaining the normal speed at each start. In this respect, location equipment is sometimes allowed slightly greater tolerances since practically all the work involves dialog only.

Special equipment is recommended for testing work when it permits quicker and better results than might be obtained otherwise. The development of such equipment usually originates with the man doing the work, and is the result of close attention to his particular equipment. Certain test equipment is supplied with a studio installation, which should be centralized and so installed as to make a

minimum amount of work necessary to put it into operation. When some test or line-up is made frequently and must be made quickly, it is often desirable to have special equipment provided for this purpose only and to have its circuit arrangement so designed as to assist in avoiding delays.

The long experience of the Bell System with communication circuits has shown that routine tests are well worth while. Routine tests are of two kinds: (*a*) *transmission testing*, to determine the condition of the recording circuit as to quality, power carrying capacity, total gain, or amplification; tube tests, power indicator device tests, tests on the recording device, be it light valve, glow lamp, galvanometer, or disk recorder; and (*b*) *equipment maintenance*, such as the periodical cleaning of contacts, adjusting of springs, blowing of dust out of equipment, checking of batteries, cords, and cables, testing of microphones, *etc.* All these tests are best done periodically, the period to be determined by experience and the man-hours required to follow the preventive routine. All tests must be consistent with actual operating conditions and must be reliable and quick.

The clearing of trouble can be considered as maintenance and the most valuable tools to a trouble shooter are experience and the knack of quick, systematic isolation of trouble. As an example, irregular popping noises were being picked up in the recording system on a stage. The microphone cords were rigged overhead and several banks of Cooper-Hewitt mercury lamps were being used. The trouble was located in one microphone cord and was then found to be due to a sputtering mercury tube. This case was the first one encountered, and it caused a serious delay; but the second time this occurred the trouble was cleared in one-third the time, and now such trouble is cleared in about one-tenth the original time. To assist in clearing troubles spare equipment should be available and no hesitancy shown to changing if production is being delayed.

A complete indexed file of drawings is also essential. Sufficient records of all tests should be kept for future reference and to keep the administrative heads informed that the proper work is being done. In this connection it should be pointed out that a complete record of all troubles should be kept, and summaries should be made at regular intervals. The purpose of this is to observe the results of the preventive routine work and to make any changes of routine that the record may indicate. Such a record is invaluable to the designers of new equipment, for it shows them the weak points in the previous

design which appeared in actual use over a period of time. Using a separate record for each trouble also prevents neglect in clearing the troubles.

To determine the efficiency of a group, several measures may be taken. From an operating standpoint one way of measuring efficiency is to obtain the ratio between the total number of production hours minus the number of hours' delay caused by trouble, and the total production hours.

$$E = \frac{T_A - T_L}{T_A} \times 100$$

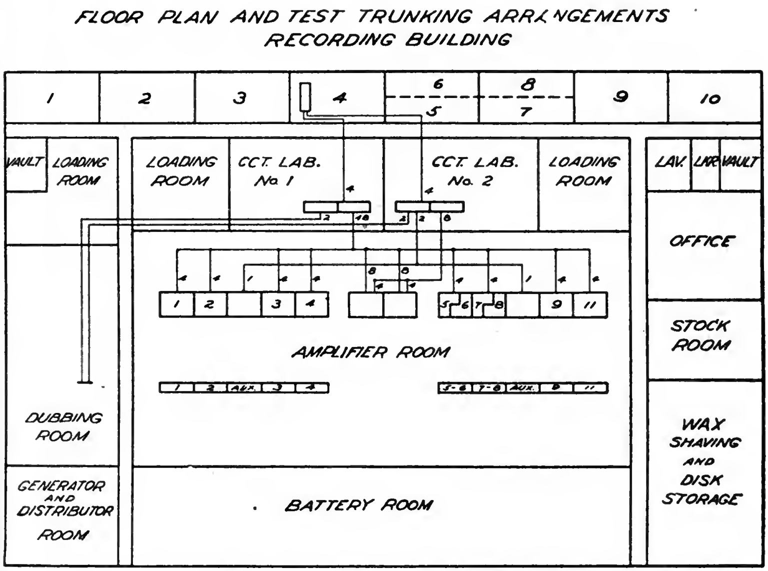

FIG. 1. Layout of large installation, showing testing trunks.

Where E = efficiency in per cent
T_A = actual production hours
T_L = production hours delay

This figure is a measure of the efficiency with which trouble is cleared. Other items of similar interest from a supervisory standpoint are the number of troubles per 100 production hours, the average time lost on the troubles causing delays in production, the total production hours, and the number of daily production crew hours compared with the production hours.

Fig. 1 shows the layout of a large installation, and indicates the

various testing trunks from the test equipment in the two circuit laboratories and from the special line-up equipment in the central section of each group of amplifiers. The line-up equipment became necessary on the introduction of noiseless recording. Prior to its installation it was required to put up six patching cords at various locations, and to dismantle any test being made on the oscillators at the time, resulting in inconvenience and loss of time. Line-up tests may now be made while the mixer on the stage is using the channel for a rehearsal by putting up three patching cords and

FIG. 2. Photograph of amplifier room.

moving only once from the channel bay to the line-up bay and back. Each channel shown in the sketch is as nearly alike as present equipment and installation limitations will permit. Fig. 2 is a picture of the amplifier room in this installation.

Fig. 3 is a photograph of a studio cable tester so mounted as to provide tests on any of the standard cables used in the plant. The keys permit testing for short circuits or leakage between any two wires of the cables.

Some months ago considerable trouble was experienced due to noise originating in the flexible stub cord on the microphone, which was

caused by turning the unit to follow the action. This was remedied by placing a simple clamp around the body of the unit to hold the cable and plug rigid, and by replacing the old flexible cord with more rigid cable. This is shown in Fig. 4, together with a cable tester for location units.

On the trunk mounted location units used, light valve tuning was difficult and relatively inaccurate, so after some thought a much simpler method was devised, using the impedance characteristics of light valves near resonance for the basis of the test. The extra

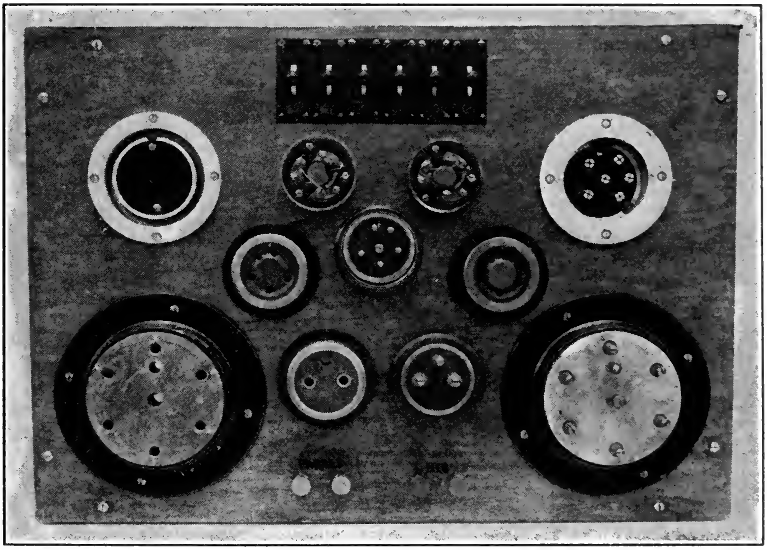

FIG. 3. Photograph of studio cable tester.

equipment necessary to do this consisted of a resistance and a special patching cord. This method allows greater accuracy, and the test may be performed in one-third the time required previously.

One of the biggest problems encountered has been that of designing new location equipment. Two years ago it was found that a number of recording systems, broken down into individual light weight trunks, was necessary. At that time no design was available. It has since been shown that the work requested of the sound department could not have been done had not such equipment been made available. It has been put into the hold of 60-foot sailboats, into the hold of a large steamer, on a 40-foot speed-boat, on a barge, on rail-

way trains, and on sleds in the snow in the mountains. Fig. 5 shows a set-up during the shooting of scenes in the Lake Tahoe region.

During the making of photoelectric cell monitoring transmission measurements, trouble frequently appears. This may be due to changes in the recording lamp illumination, and for a quick check a separate photoelectric cell amplifier with a prism was constructed to be mounted on the film recorder to receive the modulated light.

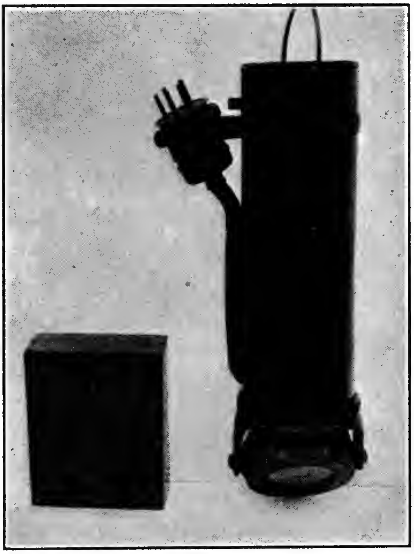

FIG. 4. Showing a clamp around the microphone for holding the flexible stub cord rigid.

With a constant given value of power on the light valve and a given amount of gain following the portable test unit the power reading at the output of the circuit should be some value previously determined for the exposure used.

The first camera motors which were developed had considerable reserve power, so that torque tests were unnecessary; however, with the adoption of smaller motors attached directly to the camera, torque tests became essential. As a consequence, the test equipment shown in Fig. 6 was designed. Camera loads, motors alone, or motors with gear-box adaptors may be checked on this device.

If the man who is responsible for the microphone boom work, in addition to the "mixer" in the booth, is able to monitor the "take" with head-phones, better recording results, since he may make slight changes in placement, depending upon what he hears. At the same time the mixer may wish to talk to the stage engineer during the "take." For this purpose an announcing system was devised by means of which the stage engineer normally monitors the "take." By operating a key the mixer cuts off the monitoring to the stage engineer and enables himself to talk out to the engineer's head-set.

FIG. 5. Location set-up in Lake Tahoe region.

An example of difficult trouble shooting with, nevertheless, a very simple solution occurred during the first few days of a picture done in Technicolor. An irregular popping noise developed while shooting the scene, causing the rejection of several takes. The author was called in, and soon the trouble was located in the arcs used on the set, but no device was able to show the particular lamp or lamp bank. The lamps were turned on, one at a time, until the noise appeared, seeming to indicate that the last one turned on was producing the trouble. However, the last several lamps turned on

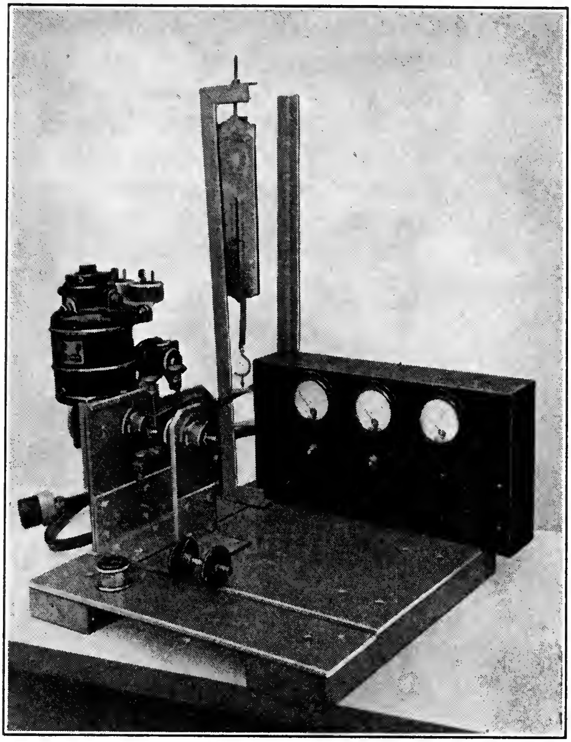

FIG. 6. Equipment for testing motor torque.

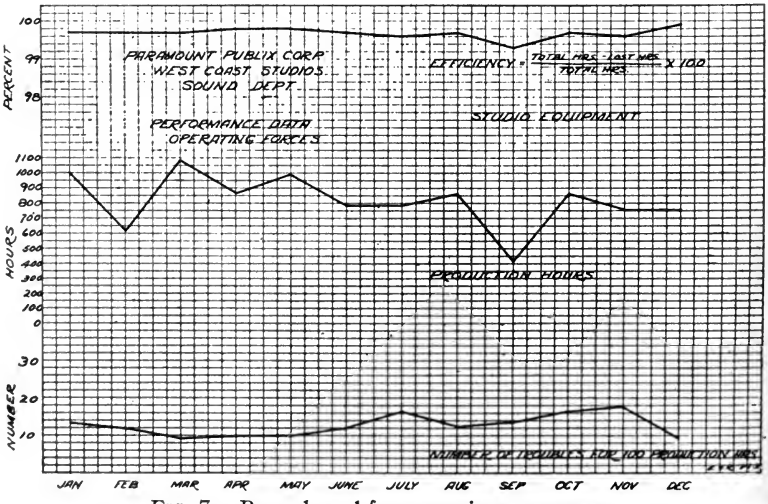

FIG. 7. Record used for supervisory purposes.

could be turned off without causing the trouble to disappear. After moving the monitor booth and rearranging the cables, the noise was reduced so that the company could proceed. The next day the same thing occurred, this time with a different booth and on a different stage. While walking around the set it was noticed that an electrician operating an arc and throwing his motor switch on and off during the "take" was causing the trouble.

Fig. 7 is a record used for supervisory purposes and shows three items, *viz.*, efficiency, production hours, and the number of troubles for 100 production hours for a year.

There are many more problems in operating recording equipment that have not been mentioned, and many more may be expected as the public demands better reproduction in the theater. Old methods and equipment are being revised and repaired and new ideas and designs are being submitted, the results of the contributions of many individuals engaged in the several branches of the art.

The point to be stressed in considering new equipment is whether an improvement in product, a decreased operating expense with no sacrifice of product, or both, can be demonstrated.

MAKING A MOTION PICTURE *

W. C. HARCUS **

Summary.—*An outline of the motion picture production problem is presented from the viewpoint of the technician. The details of picture making vary somewhat among the several studios but the general procedures and practices are essentially similar. For purposes of illustration a composite organization chart is shown and the functions of the several staff departments discussed. The operations of a typical production unit are described in some detail and a few examples of every-day problems and their solution are mentioned. All phases of the work are revised from time to time to take advantage of new methods and materials which may contribute to a better production job at lower cost.*

The motion picture engineer is, in general, a specialist concerned with some engineering or technical phase of motion picture work. Much has been said and written about the technical details of new and improved equipment and methods of operation which facilitate the mechanics of picture production, and offer means of improving the quality of the work, possibly at lowered costs. Little is generally known, however, about the motion picture studio organization which uses the engineering services and equipment in which the engineer is interested. Most of the publicity emanating from the studios pertains to the pictures and the personalities appearing in them. The purpose of this paper is to describe how a typical large studio works and to outline some of its problems as they appear to an engineer.

Large scale production of pictures requires immense capital; competent, loyal personnel; and adequate, modern plant equipment. A successful, going concern might be organized as shown in Fig. 1, and might furnish employment to as many as 2000 men and women. Heading up to a general manager will be found an executive manager and a production manager. Their functions may vary in different studios, depending on their particular talents, but the general

* Presented in the Symposium on Studio Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** Paramount Publix Corp., Hollywood, Calif.

manager is responsible for the releasing on schedule of perhaps fifty completed productions each year at a cost commensurate with the estimated box-office return and allowing for a reasonable margin of profit. This is truly a problem from the point of view of selecting that many suitable stories which will have universal appeal for a fickle public, to say nothing of producing them economically in satisfactory artistic and technical form to meet a quite rigid scheduled release date. In this part of the work the general manager may have the assistance of one or more supervisors to whom he can turn over all the managerial details of a group of pictures.

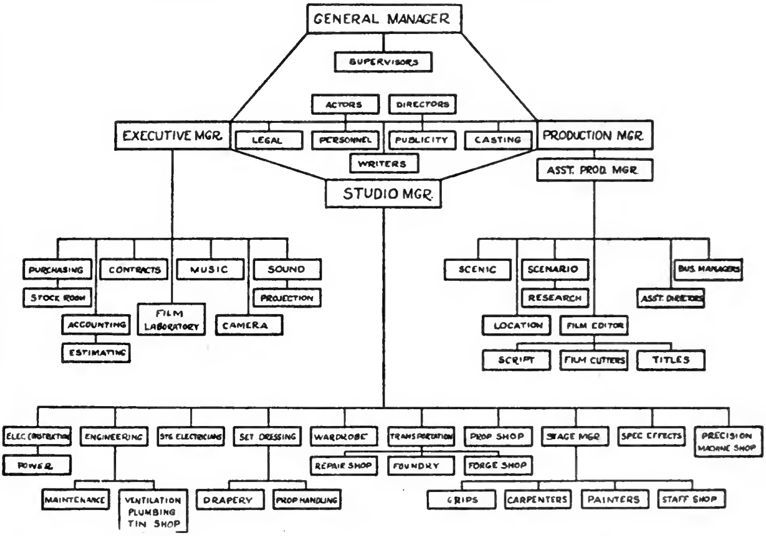

FIG. 1. Organization of a typical producing company.

The executive manager may handle contracts and financial arrangements, and a number of the staff departments such as film laboratory, camera, and sound. The production manager may handle organization and operation of production units, planning and designing of stage sets and selection of outside locations, cutting and editing of film, *etc*:

A studio manager reporting to the executive manager or production manager, or both, has charge of the studio plant operations and maintenance. Among his forces are the stage manager with the grips, carpenters, painters, and staff shop; the transportation chief with chauffeur, repair shop, foundry, and forge shop personnel; set

dressing with drapery and prop handling personnel; wardrobe, prop construction; precision machine shop; special effects department; stage electricians; electrical construction and power forces; and plant engineer, with maintenance, ventilation, plumbing, and tin shops.

Somewhere in the organization described is an individual who has the training and experience to satisfy overnight almost any demand that may arise no matter how unusual or impractical of accomplishment. It may be considered that the typical large studio with its ingenious personnel is a self-sufficient entity, dependent only on raw material supplies. A subway set is needed, and tomorrow all the fittings such as turnstiles, ticket choppers, and so on, come out of the shops complete in every detail; a jungle is required, and hand-made bamboo is created; underwater photography and sound recording are wanted, and the necessary modifications of equipment are made in time for test in the morning. Thousands of such examples could be mentioned of the work of a group of men capably working against time to satisfy a demand that cannot be met by ordinary manufacturing or supply organizations.

When a suitable story has been selected from those available, it is turned over to the writers and scenario staff who adapt it for motion picture work. Briefly, this involves the breaking down of the story into a synopsis and expansion into a script which outlines the scenes to be photographed, and the dialog and effects to be recorded. The present trend is to use dialog as sparingly as possible and to carry on the action in pantomime with sound effects. This not only assists in adhering to the more or less successful silent technic, avoids wearying the audience with meaningless chatter, but facilitates release in countries where English is not spoken. The story and scenario are often written for a particular star and with, perhaps, a group of featured players in mind

The director assigned to the proposed production goes over the tentative script with the supervisor. Revisions are suggested in the dialog, and the action is formulated and noted in the script which goes back to the scenario staff for changes. A unit business manager from the production manager's force begins to contact the studio departments, outlines tentative plans, and secures approximate estimates of costs from everyone concerned. These are consolidated with overhead and other charges by the estimating department. It is interesting to note in passing that the average error in estimating

does not exceed 5 per cent, which is quite accurate considering the number of variables. An assistant director, coöperating with the business manager, compiles a tentative shooting schedule and costume plot. The proposed production plan and estimate are then submitted to the management for approval. Changes suggested by the management to improve the production plan, or to meet budget requirements are made. Sketches of each set required are prepared by the art director, and construction drawings are made of those selected.

The final approved script and production plan then go to the studio departments for action, all work being undertaken to meet scheduled dates and estimated costs. The casting director selects players who in his judgement meet the requirements, and the cast is submitted to the director and supervisor for approval. The fortunate individuals are outfitted with costumes by the wardrobe department in accordance with the costume plot. The set construction group make up the sets in unit sections and move them to an assembly stage where each is fully assembled and where the preliminary decorating is done. After inspection the set is dismantled and stored until required on the production stage.

The staff organization of the production unit is of interest. The staff is drawn from the studio departments and works nominally under the supervision of the director for the duration of the production. The unit business manager is the representative of the production manager, and is constantly on the alert for possible economies and for keeping costs within the budget. He is responsible for seeing that sets and locations are ready when required and that the work progresses smoothly. The assistant director, as his title implies, is assistant to the director, and handles many of the details on the stage. He sees that the artists, properly costumed, are ready for work when required. The first cameraman supervises the camera crew consisting of a second camera man and assistant for each camera used. He is responsible for artistic and technically correct lighting of the set to secure the effect desired, for proper exposure of the negative and for artistic composition. The sound mixer supervises the stage engineer handling the microphone placement to obtain sound perspective and quality control, and determines the proper recording volume. He is responsible for the acoustic properties of sets and for obtaining the sound effects desired by the director. The film editor advises the director of the scenes and angles necessary for satisfactory continuity of picture and sound in

the finished production, and with the director supervises the cutting and editing.

Two script girls keep detailed records of the action photographed and the dialog recorded, the costumes used, the stage business, prop placement, and so on, so that continuity can be assured when scenes are not shot in sequence. The grips take care of moving the sets and stage equipment, and any necessary rigging. A gaffer directs the stage electricians and, under the cameraman's supervision, provides lighting equipment in the proper places and of the intensities required. The prop men provide all essential stage properties and furnishings. Technical advisors are used when accurate detail is needed, as when customs and surroundings in foreign countries are being photographed. Miscellaneous people include make-up men, hairdressers, musicians, *etc.*

So far our attention has been confined to the organization of a typical large studio and the duties of its several departments, the planning of a story from its inception to readiness for production, and the organization and duties of a production staff unit. The remaining section of the paper describes some typical problems of the production unit on the stages.

The production unit goes into reheasal a day or so before shooting is to begin, and at this time the cast becomes more or less familiar with the script and plans of the director. Perhaps the cast goes through some of the action on dummy sets. Quite often suggestions are made toward improving the dialog and stage business and, if approved, these are incorporated into the script. In the meantime the final shooting schedule is arranged by the business manager and the assistant director, each day's work being outlined in detail. The first sets to be used are moved from the assembly stage to the production stage assigned to the scene, the finishing touches are applied, and the set is rigged with the necessary lights. Furnishings and props are placed as previously planned, and the necessary equipment is moved into position.

At about 8 o'clock in the morning the staff begins to assemble and to prepare for the first set-up of the day. Cameras are placed approximately in position, and the sound recording equipment is lined up and thoroughly tested. The assistant director and the business manager make sure that no details have been overlooked. At about 9 o'clock, the director and the cast arrive and prepare for rehearsing the first scene to be taken. If the actors are experienced and are

familiar with their lines, perhaps the first take can be begun within 30 minutes. As the cast rehearses, the cameras are located so as to obtain the angles and composition desired by the director, and the lighting is adjusted to the cameraman's satisfaction. The microphone is set for correct acoustic perspective, and monitoring checks are made on the quality of the sound. A final rehearsal is made with the cameramen and sound men following the action, and if every detail seems to have been attended to, the assistant director gives the signal to make the take. The director observes the action from the vantage point of the most important camera angle, and if the take as viewed is satisfactory, he checks with the cameramen and sound men for technical approval. Ordinarily, the scene is photographed until two satisfactory takes have been made, only these being printed. This may require a dozen or more takes, between each of which additional instructions are given to the actors and the staff. An hour or more may be required to obtain a pair of satisfactory 200-foot takes, each requiring about two minutes to photograph.

It is customary for some directors first to photograph a "long shot" taking in the entire set and all the action. For this purpose one or two cameras are used, the microphone being properly located for the particular perspective. A second set of takes is made with two or three cameras, one camera photographing a "medium shot," the others taking close-ups of individuals. The microphone in this case is set for close-up quality. Occasionally a director is encountered who insists on using six or more cameras for a single take, making long, medium, and close-up shots simultaneously; but the problem of correctly lighting the set for so many angles, and the generally unsatisfactory sound and photographic results obtained make this system impracticable from a technical and economic viewpoint.

The director may split up a single scene into several short takes in order to get the angles desired and to avoid difficulty experienced in remembering lines and action. He may also shoot individual close-ups of each actor after the scene is completed, so that he can give his entire attention to detail. When it is recalled that each change in camera angle requires a re-adjustment of the lighting and of the location of the microphone, it should be easy to see why several thousand feet of film and a day's time are often required to obtain two or three hundred feet of negative suitable for the finished production. The film editor can be of great assistance to the director in visualizing the material required in the finished picture, and in helping

the director to concentrate his efforts on important parts of the work. It can be readily understood that a conscientious director might photograph from so many angles with a number of cameras as to accumulate sufficient negative for two or three different pictures telling the same story.

It often happens that the dialog or the action, as planned, does not seem timely or suitable when rehearsed. This may result in a delay while the director consults the supervisor and the writer, and revisions are made. Since, when possible, the actors are used in groups in order to economize on time, the sickness or absence of even a relatively unimportant member of the cast may disrupt a carefully scheduled program for using the stages and sets. Likewise, the failure of the director to complete each day's work as outlined may result in a disruption of the schedules of other units which may be expecting to use certain actors, sets, or properties. In such cases, the management and their representatives on the unit staffs exercise their judgment in rearranging the work to take care of the emergency, and the studio departments demonstrate their ingenuity and ability to make good in the face of difficulty.

The scenes and sequences making up a picture are seldom photographed in continuity for reasons of convenience and economy. For example, in *The Virginian* a scene was shot, reverse angle, of Gary Cooper running after Mary Brian to save her from a tame cow, the next flash showing them coming toward the camera. The two takes were made 400 miles apart and two weeks had elapsed between them. It may be somewhat of a strain on the actors and the director to maintain the tempo and the illusion of continuity on this basis, but by referring to the previously completed work and to the detailed records of the script girls, an acceptable result is usually obtained. It would be highly embarrassing to produce an expensive day's work with an actor wearing a different collar or tie, a hat of different shape, or perhaps even with a different quality of make-up, since, if such a scene were allowed to go into the finished picture a deluge of mail criticizing the inaccuracy would be received. Adherence to a policy of accuracy in detail means records in usable form, and the experienced script girls, wardrobe, and prop men not only keep the records, but can produce the information and the apparel and props at what is often a moment's notice. Even more important is the forethought necessary to have on the job when working at a place remote from the studio warehouses all the material which might

be required. Ingenuity must supply items which are overlooked. For the making of *Fighting Caravans* in the high Sierras long two-inch hawsers were supplied which were found inadequate for use. Steel cables were drafted into service from near-by mines. Snow covered the location unexpectedly and some of the work had to be matched with snow sequences taken the previous winter. Microphones had to be adjusted in the field for operating conditions unforeseen by the maker—temperatures between 20° and 85°F., and atmospheric pressures corresponding to changes of altitude of from sea level to 10,000 feet. Imagine the forethought of the man who had provided for overshoes and boots, raincoats and heavy clothing, adequate food and equipment, for a unit to carry on comfortably, isolated four days from even a telephone, sixty miles from the nearest town, during a snowstorm in August in California.

Some of the most interesting shots are those made with a moving camera, and the rigging employed for some of these is quite ingenious and practical even if cumbersome and junky in appearance. Such a truck with camera blimp, lights, and microphone, carrying a cameraman and with several grips supplying the motive power and handling the lighting, camera, and sound cables could only be depicted in a well-known cartoon strip. Interesting mechanical arrangements have been developed to care for this work, including elaborate cranes, elevators, tracks, motor-driven dollies, and so on, each having valuable applications depending on the space available on the stage and the effects wanted.

The making of "effect shots" is a fascinating story and all that can be said within the scope of this paper is that the use of transparency processes, still and moving backings, miniatures, glass shots, zoom and other special lenses, and so on, make it convincingly possible to accomplish the impossible and to effect remarkable economies in production.

Subsequent to the completion of the approved first cut of the picture, further work is done on the scoring and dubbing stages. These stages lack the glamor of the production stages but they make an important contribution to the effectiveness of the finished picture. The services of experienced musicians and skilled technicians are called upon to create composite sound negatives which are substituted for sections of the original. In *Rango*, for example, the peculiar chattering at sunrise of gibbons, a species of monkey, was needed to produce a desired effect. The technicians visited a zoo at day-

break several times to obtain an authentic record. Many studios have a staff of musical composers and arrangers who contribute much to the smoothness and entertainment of the completed job. Incidental music and effects are seldom recorded on the production stage on account of the limitations which would be imposed on cutting.

The final steps include a review of the complete cutting print by the management; the printing of a movietone copy for preview; the approval for release printing subsequent to minor changes made as a result of studying the public's reaction at the preview.

DISCUSSION

PRESIDENT CRABTREE: What is the Paramount transparency process? How does it differ from the Dunning Process?

MR. HARCUS: Patents for the Paramount transparency process were applied for December 19, 1925, and granted June 12, 1928. Patents for the Dunning process were applied for April 17, 1926, and granted January 4, 1927. Both processes deal essentially with complementary colors, both as to film sensitivity and lighting, to induce one subject or background into another subject so that the final finished result will appear as though both subjects were photographed at one and the same time. The Dunning process, as applied for, differed essentially from the Paramount process in that Dunning induced a negative balanced image in his colored background or key plate, which was supposed to care for what is known as "ghost" or "phantom," more clearly described as the showing through of one object into another when superimposed. This necessitated balancing three factors, which was found extremely difficult. The Paramount process required the balancing of only two factors, which proved to be a more practical solution to the problem, and gave little trouble due to "ghost."

Early in 1930 Mr. Dunning received an exclusive license from the Paramount Publix Corporation to use the Paramount process in his service to other producers. All transparency work in the Paramount releases has been and still is handled by the studio personnel.

MAKING MOTION PICTURES IN ASIATIC JUNGLES*

GORDON S. MITCHELL**

Summary.—*This paper describes some of the difficulties encountered in sending a motion picture company into a faraway country for the purpose of obtaining realism in production. It describes in detail the difficulties encountered in preparing the company for departure, and those experienced after arriving in the Malay States. The problems attending the sound and camera equipment, in transporting the exposed film to the laboratory in time to avoid deterioration, the experiences with the natives who had been engaged to supply "atmosphere" for the picture, the particular difficulties encountered in recording sound in inaccessible places, and a few more or less personal experiences of the technicians who accompanied the expedition, are all described.*

When the Universal Pictures Corp. decided to send a motion picture company to Borneo to film an adventure picture, they realized that they were inviting problems that would take more ingenuity, more actual pioneering, on the part of the sound personnel accompanying the troupe than had ever before been necessary since the addition of sound to motion pictures. Accordingly, they selected from among the sound technicians at the Pacific Coast Studios two men whose wealth of experience admirably fitted them for the work—Mr. Clarence Cobb, who went along as amplifier man, and Mr. Fred Feichter, who was responsible for mixing and recording. These two men together brought back approximately ninety thousand feet of sound records obtained under the severest conditions imaginable.

The company consisted of two sound technicians, a first and a second cameraman, two laboratory technicians, a director, a business manager, a production manager, a secretary, and two actresses. In addition to the personnel, twenty-three thousand pounds of baggage were taken, including sound equipment, camera equipment, a complete laboratory, projection machines, and a sound play-back machine.

The tremendous amount of preparation that was necessary before the departure can hardly be imagined. It was necessary to list every

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Sound Department, Universal Pictures Corp., Universal City, Calif.

item to be taken along; its value, its make, whether foreign or American; and its weight. These lists were made out in quadruplicate; two were sent to the customs authorities; one was kept always with the baggage; and one was filed at the studio. It was necessary to note on these lists not only complete assemblies, such as cameras, but every item that goes to make up each assembly as well. Lens, lens holders, and even take-up screws, had to be listed separately in the customs lists. Each department of the studio organization was responsible for the material needed by the members of that department in the Orient, and was charged with the preparation of that material for shipment.

Everything was in readiness for the departure early in May of last year. The company left the studio and traveled directly to Vancouver, where it embarked for Hong Kong on the Canadian Pacific steamer, *Empress of Russia.* At Hong Kong, after pausing briefly to film Chinese street scenes for the picture *East is West,* which was then in production at the studio, a transfer was made to the P. and O. steamer *Kiver,* sailing for Singapore. The company arrived at Singapore on the fourth of June.

Complete laboratory equipment must always accompany an expedition of this kind in order that the film may be developed soon after exposure so as to avoid deterioration. Due to inherent characteristics of sensitized film, if sound track is not developed within approximately twenty-four hours after exposure, the film will deteriorate, resulting in a loss of the high frequency components of the recorded sound. Consequently it was always necessary to set up the laboratory unit within about twenty-four hours' traveling time of the production unit. The negatives were developed daily, one print of each negative being made for the use of the location company. The negatives were held and sent back to the studio about once a month.

The company, arriving at Singapore, began to make plans for shooting the picture. The laboratory unit was set up in a rented building, while the production unit traveled four hundred miles up the east coast of the Malay States to a small fishing village named Quantan. Two weeks were spent in filming and recording certain village sequences of the picture. The arrangements for transporting the exposed film to Singapore each day presented one of the first complications of the trip. Every night after the day's shooting had been completed, the exposed film was dispatched by automobile to

the railway terminal one hundred miles away. It was then put aboard the morning train, which arrived in Singapore early the same evening. The all-night automobile trip to the railway terminal was made entirely through jungle, where it was a common occurrence to encounter one or two trees that had fallen across the "highway." Several times after the frequent tropical storms the driver was so delayed by chopping through the fallen trees that he missed the train.

After the village sequences were completed, the jungle river sequences were filmed. With the base of supplies still in Quantan, the company traveled daily about three hours by boat up a river into the interior. The first fifteen miles were negotiated by motor boat. The equipment was then transferred, piece by piece, to native rafts, which were rowed up a tributary for eight miles. This tributary varied in width from fifteen to twenty-five feet. Thirty natives accompanied the expedition to assist in transporting the rafts up the stream. Whenever a snag impeded the progress of the boat, some of the natives would go over the side and push the boat off. In many instances it was necessary to unload the boats entirely, and to portage the equipment around obstructions in the stream, after which they were reloaded and the trip was continued.

A Johnson outboard motor was taken along, and used at times to propel the raft up the river. This motor was the cause of much astonishment to the natives, who were unable to understand how it was possible to move the raft through the water without manual labor.

Three Bell and Howell cameras and an Akeley sound camera were taken along. The Akeley sound camera was an innovation sponsored by Electrical Research Products, Inc., and comprised a camera and sound recorder built as a unit. The recorder consisted of a light valve which differed slightly from the usual valve in that it included a recording light and was covered with a cup-like case. This recording unit was mounted on the back of the camera, and the sound track and picture frames were exposed on the same film at the same time, with the differential of nineteen frames which is usual for the release print. This is rather unusual as it is common studio practice to record the picture on one film and the sound track on another, the two films going through the cutting and editing processes separately, after which the sound and action are printed on a single film known as a "composite print."

However, the film as exposed in the Akeley sound camera is, on exposure, identical in form to the usual composite print. The mixing and amplifying equipment were all mounted in separate carrying cases to provide for easy handling during transportation, and were strongly built so as to withstand the rigors of primitive jungle travel. Rubber covered cables having suitable end connectors were used for connecting the various units of the equipment, making it possible to set up the mixer and amplifiers some distance away from the camera and recorder if for any reason it happened to be inconvenient to set up all the equipment in close proximity to it.

After spending about five weeks in and around Quantan, the company returned to Singapore and prepared to depart for Java. A small steamer was chartered, and the laboratory was set up on board, with darkrooms and all of the necessary apparatus for developing and printing while *en route*. A month was spent on the journey, the troupe leisurely traveling down the coast stopping to work at appropriate points. Several side trips were made inland to photograph jungle scenery, one trip being made up a small river as far as a hundred and fifty miles. Soerabaja, Java, was the next port of call, where the company left the steamer and again separated. The laboratory unit was set up in the town, while the production unit went into the jungle about two and a half hours by automobile from Soerabaja.

During this part of the trip transportation difficulties were very few, as far as getting the exposed film to the laboratory was concerned. It was a simple matter to send an automobile into Soerabaja every night with the film. Some or all of the technicians usually went in to view the "rushes"—corresponding to usual studio practice, when everyone connected with a picture sees the preceding day's work on the screen the evening after the day's shooting is finished. A point of interest anent the "rushes"—the natives often were allowed to view the scenes in which they had appeared; they would become as excited as children, pointing each other out as the various characters appeared on the screen, chattering and talking among themselves. The town clown, of course, was always present during the shooting of the scenes, attempting to show off his prowess before the camera, and differing not a bit from his counterpart seen in any American crowd on any city street. An interpreter whose duty it was to listen carefully to all incidental conversation, was always present when the natives were working before the camera. The natives seemed to delight in making

"wise cracks" in their own language, which, if translated, would pass no censor.

The handicaps under which the sound was recorded in the jungle can hardly be imagined. In the first place, the sound equipment was new in design. It had, of course, been tried out in the laboratory under routine conditions, but no one knew exactly how it would stand up "under fire." Messrs. Cobb and Feichter were given a highly complicated piece of electrical equipment, with which they were as familiar as anyone, it is true, yet which had never been used in actual production, and were sent away into a far corner of the earth, remote from all help, to record the sound for a motion picture. The fact that they acquitted themselves as well as they did is a high compliment to their ability as sound technicians.

The very inaccessibility which lends the principal charm to the finished picture furnished difficulties all but insurmountable. In one instance, it was desired to photograph and record scenes in the heart of the jungle more than a mile from the nearest road. This meant that more than a ton of recording equipment, alone, had to be transported by native bearers through dense vegetation. A roadway was cut through the jungle, but the growth was so dense that the weight of the vines and treetops above the roadway caused them to press down upon those adjacent, so that the vegetation seemed to close in behind as the road was cut. Constant effort had to be expended to keep the pathway clear while the company was working in this particular setting.

Extraneous noises presented other problems for the sound technicians. Rivers, so numerous in that part of the world (the average yearly rainfall varying from forty to two hundred and forty inches) roared and rippled so that it was almost impossible at times to record acceptable dialog above the noise of the water. While it was desired to record sounds as they actually were in the jungle, often the noise due to the great abundance of animal life made the dialog unintelligible. When the company would first set up the equipment in the jungle, everything would be quiet. However, after a short time the noise would begin, gradually growing louder and louder. It would then be necessary for someone in the company to make a noise to frighten the animals away—birds, in many cases. Silence would follow for a short interval, after which the same procedure would again have to be followed. One species of bird which was particularly troublesome emitted a constant buzz, much like a locust,

made by rapidly tapping a tree trunk with the beak. The buzz of flies and insects was very troublesome when recording sound, and caused much annoyance to the members of the company. Small monkeys would run about and chatter constantly, entirely devoid of fear for the white man.

Not only was the abundant animal life the cause of much thought on the part of the sound technicians, but it at times proved to be the cause of much consternation on the part of all from a personal standpoint. There are no glass windows in any but the largest hotels in that part of the world, and it was often necessary to sleep in houses which were partially open at the top. Small lizards would run about the bed, and small monkeys about the room, especially in the smaller jungle villages. The nights would be disturbed by small lizards and animals dropping into the room and onto the bed, but after a few weeks in the jungle, such occurrences ceased to disturb the tired motion picture technician. Signs along the road warned passers-by to beware of the black panther if traveling by night. This panther is a hybrid species, very agile and a facile tree climber, which makes it particularly dangerous. Incidentally, this panther is of great interest to the zoölogist, as it is claimed to be a throwback from centuries of evolutionary development. Although the spotted panther is decreasing in numbers, the black panther is increasing. The result of the mating of two spotted leopards is periodically a litter of all-black kittens, in which there will be no spotted offspring. This birth of a litter of black kittens will happen once every five or ten years, between which intervals there may be born several litters of spotted offspring.

The high temperature encountered in tropical regions would, of course, play havoc with solutions as used in the laboratory. Consequently, two General Electric cooling units, similar to those used in electric refrigerators, were taken along. One of these was used to keep the "soup" cool, while the other was used to cool the water used in the laboratory and by the company. All water used had to be distilled.

The extreme humidity of the tropic regions affected the condenser microphones to a considerable extent, and the other equipment to a slightly lesser extent. It was necessary to place all sound equipment in a drying chamber at night. Although this chamber was normally heated by a number of incandescent lamps, the inadequate power supply in most places often made it necessary to place several Coleman lanterns inside to furnish additional heat. Constant precautions

were necessary to keep wires from corroding. Mildew formed overnight on any piece of equipment which was allowed to become in the least bit damp. Every minute of the time meant a struggle against the tropical climatic conditions. Electrical energy was furnished by storage battery sets. A gas engine generator was carried to charge the storage batteries, but often was back on the "second lines" at the laboratory headquarters. At such times, it became necessary to make local arrangements for charging, either with public or privately owned power systems. At one of the locations in the Malay States a home lighting plant belonging to a wealthy Chinese trader was used for charging the batteries. The public power systems, where they existed, were operated at two hundred and thirty volts, the standard voltage throughout the Orient. This voltage, differing so much from that used throughout the United States, somewhat complicated things when it became necessary to interchange particular pieces of electrical equipment.

Language problems were continually presenting themselves. Most of the natives, of course, were unable to understand a word of English, just as the people of the company were unable to understand the native tongue. Interpreters were engaged at each stopping place, but could not function for all members of the company at the same time. When it was necessary for several negotiations with the natives to be carried on at the same time, the sign language was called in to substitute for the spoken word. In fact, so proficient did Mr. Cobb become in the sign language while he was in Java that he was able to carry on an entire conversation without speaking a word. The natives are inherently gifted in the art of pantomime, and often use the sign language among themselves.

While in the Malay States, Mr. Galezio, the cameraman, and his assistant flew over Mt. Bromo, an active volcano ten thousand feet in height. The plane circled the mountain at fifteen thousand feet, after which it dropped down to within five hundred feet of the crater. Some very spectacular photographs were obtained. Although in tropical regions, the temperature was below freezing. The air was very "bumpy," especially close to the surface of the crater. As the volcano blows off at unexpected moments, this trip was made against the advice of those familiar with the territory.

Automobile transportation in this part of Asia is quite curious. There is a law to the effect that every car must carry two horns—the usual electric horn, in addition to one of the old bellows type, which

is to be used in case the electric horn fails. The old types of horns are very popular among the native drivers, who sound them constantly while driving, even though they may be twenty miles away from the nearest village and in the heart of the jungle. Automobiles have right-hand drives, and two drivers are required on every car. One does the driving, while the other is charged with the responsibility of keeping his partner awake. On long trips they exchange duties periodically. The driver is entirely responsible, and not the car owner, for any accident or untoward event that might happen. Side mud guards are placed on every car to prevent pedestrians from being splashed with water. It is a serious offense to permit the automobile to splash water on anyone in the Dutch East Indies, and the driver of the offending car is likely to be punished for his misdeed.

Whippets and Hupmobiles are most often seen on the islands of the Dutch East Indies, and there are very few European cars. There are not many Fords or Chevrolets, but the contemplated Ford factory in Asia will no doubt do much to increase the use of Fords in this part of the world.

The expedition was undertaken to film the story of the ourang, simian native of the region. Several of the beasts were captured, and appeared in the picture. One in particular weighed three hundred and eighty pounds, and possessed a physical strength quite commensurate with its bulk.

After nearly four and a half months in the tropics, the last scene was shot on October 16th, and the company left almost immediately for California. They arrived at Vancouver on November 22nd, where they were met by Mr. Jack Lawton, location manager for Universal Pictures Corp., representing the company. The equipment was checked, and it was found that not one piece of sound or camera equipment had been lost during the entire trip.

The final scenes of the picture are now being filmed in the studio—close-ups and a few interiors—and the results of the work of four and a half months of intensive motion picture endeavor, *East of Borneo*, will soon be released for public showing.

The writer wishes to thank Mr. Jack Lawton, location manager, Universal Pictures Corp., Mr. Clarence Cobb, sound technician, and Mr. Len Galezio, for valuable aid and information in preparing this paper.

GLOSSARY OF TECHNICAL TERMS USED IN THE MOTION PICTURE INDUSTRY

A revision of a previous glossary prepared by the Committee on Standards and Nomenclature. The terms included in the following glossary are those which are in common use among motion picture engineers. Since motion picture engineering is essentially a combination of other well-recognized branches of engineering, such as electrical, chemical, illuminating, etc., it is to be expected that many of the terms used by motion picture engineers have already been standardized by other engineering societies. For this reason, the definitions approved by such societies as the American Institute of Electrical Engineers, the Institute of Radio Engineers, the Illuminating Engineering Society, etc., have been adhered to as closely as possible in the preparation of this glossary. In some cases, the definitions proposed by these societies have been included verbatim.*

Aberration.—A deviation from the ideal in the performance of lenses which impairs the quality of the images they form in respect to either definition or geometrical similarity to the object.

Acetate film.—Film of which the base is composed principally of cellulose acetate.

Actinic.—Capable of effecting chemical or electrical changes by means of radiant energy.

Acoustic flat.—(See *Flat.*)

Additive process.—The process for reproducing scenes in color, using a restricted number of primary component colors, in which the composite image is produced by a *mixture of beams of light* having separate origins, either in time or in space.

Alternating current.—Current, the polarity of which reverses periodically, due to the periodic alternation of potential of the generator producing it, and the algebraic average value of which is zero.

Alternating current, damped.—A current, the values of which pass through successive cycles with progressively diminishing amplitude.

Ampere.—The practical unit of measure of electric current. It is equal to $^1/_{10}$ the c.g.s. unit of current, and is defined as the practical equivalent of the unvarying current which, when passed through a solution of silver nitrate in water in accordance with standard specifications, deposits silver at the rate of 0.001118 g. per second.

* *Transactions, Soc. Mot. Pict. Eng.*, **XIII** (May, 1929), No. 37, p. 48.

Amplification, current.—The ratio of the alternating current produced in the output circuit of an amplifier to the alternating current supplied to the input circuit.

Amplification, voltage.—The ratio of the alternating voltage produced at the output terminals of an amplifier to the alternating voltage impressed at the input terminals.

Amplification, power.—The ratio of the a-c. power produced in the output circuit of an amplifier to the a-c. power supplied to the input circuit.

Amplification factor.—The ratio of the change of plate voltage of an electron tube to the change of grid voltage in the opposite direction, determined under the condition that the plate current remains unchanged. In exact usage, the term applies only when the changes in the potentials are infinitesimal.

Amplitude.—The maximum instantaneous value which any variable may attain when varying according to a periodic law; as applied to a-c. circuits, the maximum value which the current or voltage may attain during either half of the cycle.

Angle of incidence.—The angle that a ray of light incident upon a a surface forms with the normal to the surface.

Angle of reflection.—The angle that a ray of light reflected from a surface forms with the normal to the surface. This angle is equal in magnitude to the angle of incidence.

Aperture.—The opening in the aperture plate of a camera, projector, recorder, or printer at which (*a*) each individual picture or (*b*) the sound track is situated during exposure, printing, or projecting. (See also *Effective aperture* and *Relative aperture.*)

Aperture plate.—In a camera, recorder, printer, or projector, a metal plate containing an aperture.

Arc (electric).—A bridge or column of incandescent vapor which carries an electric current that sustains this condition.

Aspheric.—In general, non-spherical. In optics, usually applied to surfaces of revolution generated by the rotation of a curve other than a circle.

Astrogamma.—The slope of the linear portion of the curve that shows the relation between the diameter of the image of a point source of light, and the common logarithm of the exposure.

Attenuation equalizer.—A device for altering the transmission characteristics of a circuit at various frequencies in order to obtain a

more desirable transmission characteristic at all frequencies within a certain range.

Back focus.—The distance from the second principal focus of a lens to the vertex of the nearest refracting surface.

Beat.—A complete cycle of amplitude variations resulting from the interference of two or more periodic waves of different frequencies.

Bel.—The bel is the unit of measure of the ratio of two amounts of power, the number of bels corresponding to any given ratio of two amounts of power being the common logarithm of this ratio.

Blooping patch.—A black section, approximately triangular in shape, introduced over a splice on a positive sound track to prevent noise which the splice would otherwise cause during reproduction. The patch effects a gradual diminution of the light transmitted through the sound track, followed by gradual restoration to the original value. The patch may be applied with black lacquer or may be a triangle of black paper or film cemented on the track. The same result can be accomplished by punching a triangular hole in the negative before printing.

Brightness.—The luminous intensity (candle power) per unit of projected area of a radiating or reflecting surface, the projection being made on a plane normal to the direction in which the brightness is observed.

Calibrate.—To determine the correct scale intervals for any measuring device or to ascertain the errors of the scale, such as marking the focusing scale of a camera lens, or determining the errors in the readings of a thermometer.

Camera angle.—The angle of view subtended at the lens by the portion of the subject included within the picture area. It usually refers to the horizontal angle.

Candle (international).—The unit of luminous intensity. The standard candle has been maintained since 1909 by means of incandescent lamps at the National Standardizing Laboratories of France, Great Britain, and the United States.

Candle power.—The luminous intensity of a source, expressed in candles.

Change-over.—In projection, the act of changing from one projector to another, preferably without interrupting the continuity of projection.

Channel.—(See *Recording channel.*)

Cine.—A prefix used to refer to the motion picture art, or motion picture apparatus.

Cinephotomicrography.—Motion picture photography through a microscope.

Circle of confusion.—The spot of light of finite size which constitutes the optical image of a point. The *circle of least confusion* is the smallest circle of confusion obtainable with the best adjustment of focus.

Close-up.—A photograph in which the major subject occupies a large portion of the film frame.

Color screen.—(See *Filter.*)

Color temperature (of a light source).—The temperature (usually expressed in degrees K.) at which a true black body will match the color of the source of light.

Colorimetric purity.—The degree of freedom of a color from admixture with white.

Condenser (optical).—A lens or combination of lenses used to gather light from a source and converge (condense) it, as upon the aperture of a projector, or into an intense spot of light for use in a theater, *etc.*

Condenser (electrical).—A device consisting of two electrical conductors separated by a non-conducting medium, used for storing electrical energy.

Continuity.—A detailed form of scenario giving a complete description of each scene. (Same as *Script.*)

Contrast.—(*a*) The range of tones in a photographic negative or print expressed as the ratio of the extreme opacities or transparencies or as the difference between the extreme densities. (*b*) A property of any type of photographic material descriptive of its ability to differentiate between tones in the subject.

Cut-back.—A scene in a motion picture which reverts to a previous action.

Cut-in.—An incidental scene or subject, inserted in a motion picture, which breaks the continuity.

Cutting.—The selection and arrangement in the proper sequence of the various scenes in a motion picture.

Cycle.—A complete set of recurrent values of a periodic phenomenon.

Damping.—(See *Alternating current, damped.*) Causing a decay or decrement in the amplitude of any vibratory phenomenon.

Decibel.—One tenth of a bel. The symbol "db." is commonly used for the decibel.

Definition.—(See *Sharpness.*)

Density (photographic).—The common logarithm of opacity.

Depth of field.—The range of object distances within which objects are in satisfactorily sharp focus.

Depth of focus.—The range through which a photographic plate or film can be moved forward and backward with respect to the lens while maintaining satisfactorily sharp focus on an object at a given distance. (This term is very frequently misused in the sense of depth of field.)

Developing.—Chemically treating exposed photographic film to convert the latent image to a visible image.

Diaphragm (optical).—A device, such as a perforated plate or an iris, which limits either the aperture of a lens, the field covered by the lens, or both, depending on its location.

Diaphragm (acoustical).—The disk of a loud speaker, which is caused to vibrate by electrical impulses, thereby becoming a source of sound; also a disk in a microphone which is caused to vibrate by impinging sound waves.

Diffuse density.—The value of density as measured with diffuse light. (See also *Specular density* and *Q factor.*)

Direct current.—A unidirectional current, as from a battery.

Dissolve.—The gradual transformation of one scene into another. In a *lap-dissolve*, the fade-in of one scene is superimposed upon the fade-out of the other. This may be accomplished by double-exposure or by double-printing.

Distortion (electrical or acoustical).—A change in form. A wave-form may be distorted by: (*a*) the addition of components having frequencies not originally present, due to circuit elements having non-linear characteristics; (*b*) a change in the relative amplitude of the various components; or (*c*) a change in the relative phase of the various components. Two or more of these forms of distortion may exist simultaneously.

Distortion (optical).—An aberration of lenses which causes them to image straight lines in the margin of the field of view as curves. If the curvature is convex toward the center of the field, the distortion is said to be "pin-cushion" shaped; if the curvature is concave toward the center of the field, the distortion is called "barrel-shaped."

Double-exposure.—The exposure of a strip of film twice, as in making lap-dissolves and in special-process photography.

Double-printing.—Exposing a film under two negatives successively, prior to development.

Douser.—A fire-proof shutter, usually mounted on the lamp house of a projector, by means of which the light may be cut off before it reaches the film or slide.

Dubbing.—Re-recording a sound record by electrical means. The operation may involve transference from a film record to a wax record, wax to wax, film to film, or wax to film. Dubbing is used for editorial purposes, for altering volume levels, and for inserting incidental sounds, such as musical accompaniment, background noises, *etc.*

Dupe.—A duplicate negative made by printing from a positive film or by printing from a negative and reversing.

Effective aperture.—The apparent diameter of a lens viewed from the position of the object against a diffusely illuminated background, such as the sky.

Emulsion.—A mixture of light-sensitive material, such as a silver halide in a very finely divided state, in a medium such as gelatin.

Equalizer.—(See *Attenuation equalizer.*)

Exposure.—(*a*) In general, the length of time that a light-sensitive material is allowed to be acted upon by light; (*b*) the product of the time of exposure and the intensity of the illumination.

Exterior.—A scene which appears to have been taken out-of-doors.

Fade-in.—A gradual appearance of a projected picture from total darkness to full-screen brilliancy.

Fade-out.—A gradual disappearance of a projected screen image.

Fader.—A device employed to vary the output volume of sound projectors, and to permit a gradual sound change-over from one projector to another at the end of each reel.

Farad.—The unit of capacity (capitance) in the practical system of electrical units. It is equivalent to 10^{-9} abfarad, the unit of capacity in the c.g.s. electromagnetic system. The common unit of capacity is the microfarad, which is equal to one-millionth of a farad.

Feature.—A motion picture designed to form the main part of a film exhibition program.

Feed-reel.—A reel from which film is pulled by sprockets or other means before passing through the projector.

Field of view.—(See *Camera angle.*)

Film.—(*a*) A flexible, transparent support upon which a light-

sensitive emulsion has been coated. (*b*) A processed strip of such material containing a series of photographic or dye images.

Film-gate.—A device for holding a film against an aperture plate.

Filter (*electrical*).—A selective network which freely transmits electrical waves having frequencies within a certain continuous frequency band (or bands) and which attenuates substantially electrical waves having other frequencies.

Filter (*optical*).—A transparent material characterized by selective absorption of light according to wavelength. The term *neutral filter* is often applied to materials which absorb light of all wavelengths to approximately the same extent.

Filter (*mechanical*).—A mechanical impedance or a combination of impedances so designed as to pass or suppress mechanical vibrations of certain frequencies.

Filter factor.—The ratio of the time of exposure required to produce a given photographic effect when a filter is used to the exposure required to produce the same effect without the filter. In stating a filter factor, it is necessary to specify both the color-sensitivity of the emulsion and the quality of the radiation.

Fixing.—The chemical process of making a developed image permanent by removing the undeveloped light-sensitive substances.

Flash.—A short scene, usually occupying not more than three to five feet of film.

Flash-back.—A short cut-back.

Flat.—A section of painted canvas, thin board, or the like, used in building sets. An *acoustic flat* is a flat constructed primarily for acoustic control.

f/-number.—The ratio of the focal length of a lens to its effective aperture. A measure of the "speed" of a lens.

Focal length.—The constant of a lens upon which the size of the image depends. In a thin lens it is the distance from the center of the lens to either principal focus; in a thick lens or a compound lens, the distance from either principal point to the corresponding principal focus.

Focal plane.—A plane perpendicular to the axis of a lens through the image of a given object.

Focus or *focal point* (*noun*).—The point at which a lens produces the smallest image of an object-point at a given distance. The *principal focus* is the focal point obtained when the object is at an infinite distance.

Focus (verb).—The act of adjusting the position of a lens with relation to the surface upon which the image is formed so as to obtain the sharpest image of the object.

Footage.—The length of motion picture film measured in feet.

Foot candle.—A unit of illumination. It is equal numerically to one lumen per square foot.

Frame (noun).—A single picture of a series on a motion picture film.

Frame (verb).—To bring a frame into register with the aperture during the stationary period.

Frame-line.—The dividing line between two frames.

Frame-line noise.—Noise due to maladjustment of the optical system of a reproducer, caused by the interruptions by the frame lines of the light passing to the photoelectric cell.

Frequency.—The number of cycles per second.

Fundamental frequency.—The lowest frequency in a harmonic series.

Gain (of an amplifier).—The increase of power at any given point in a circuit due to the insertion of an amplifier in the circuit. The gain is usually measured in decibels.

Gain control.—A device, usually a passive network, used for varying the gain of an electrical system. The gain control commonly used in connection with sound reproducing apparatus consists of a simple resistance network, so designed that the gain can be changed in steps of from one to three decibels.

Galvanometer.—An instrument for measuring electric current, for detecting its presence in a circuit, or for determining its polarity. In sound-recording practice, special forms of the galvanometer are sometimes used to modulate the light beam.

Gamma.—The slope of the straight portion of the H & D curve of a photographic material.

Glow-lamp.—A lamp in which light is emitted by a gaseous discharge. Some methods of recording sound employ a special type of glow-lamp in which the intensity of the glow is controlled by the recording amplifiers.

Graininess.—The effect of inhomogeneity exhibited by silver deposits due to the presence of groups or clumps of silver particles.

Ground noise.—Noise due to irregularities, imperfections, abrasions, or foreign matter in or on a film or disk record.

Guide roller.—In a motion picture mechanism, a roller for positioning the film in relation to a sprocket, film gate, *etc.*

H & D curve.—A graphical representation of the relation be-

tween the density of a developed photographic image and the common logarithm of the exposure.

H & D speed.—The quotient obtained by dividing the number 10 by the inertia expressed in candle-meter-seconds.

Halation.—A halo surrounding the image of a bright object in a photograph, caused by reflection of light from the rear surface of the plate or film

Harmonic.—A component of a periodic quantity having a frequency which is an integral multiple of the fundamental frequency; for example, a component whose frequency is twice that of the fundamental frequency is called the second harmonic.

Image.—A reproduction by a lens or mirror of an object (or another image) made possible by the ability of the lens or mirror to reunite approximately into an image-point all the rays of light that it receives from the corresponding object-point.

Image, latent.—The effect produced by the action of light on a light-sensitive material which renders it capable of development.

Impedance.—The property of an a-c. circuit by virtue of which it tends to oppose the flow of current; the ratio of the applied voltage to the current flowing in the circuit; the resultant or vector sum of resistance and reactance.

Inertia (of a photographic emulsion).—The value of exposure corresponding to the intersection of the extrapolated straight portion of the H & D curve and the exposure axis.

Intermittent sprocket.—The sprocket that engages the film and gives it an intermittent movement at the picture aperture.

Interior.—A scene which appears to have been taken indoors.

Iris.—An adjustable diaphragm composed of thin plates; so called because its action resembles that of the iris of the eye.

Irising.—Opening (irising-in) or closing (irising-out) an iris diaphragm.

Kerr cell.—A cell containing a pair of electrodes submerged in a liquid of such a nature that it will rotate the plane of polarization of a beam of polarized light when an electrostatic field is set up between the electrodes. Kerr cells are used in certain systems of photographic recording.

Lambert.—A unit of brightness. The uniform brightness of a perfectly diffusing surface emitting or reflecting one lumen per square centimeter. For most purposes, the millilambert (0.001 lambert) is the more convenient unit. Brightness expressed in candles per

square centimeter is converted into lamberts by multiplying by π.

Lantern slide.—A single transparent picture designed for projection. Usually the picture is on a glass slide $3^1/_4$ by 4 inches in size.

Leader.—A piece of blank film attached to the beginning of a reel of film for threading into motion picture apparatus.

Lens.—(*a*) A piece of glass or other transparent material having two polished surfaces, both of which may be curved, or one may be curved and the other plane. A lens that is thinner at the center than at the edges is called a negative or diverging lens; one that is thickest in the center is called a positive or converging lens. (*b*) A combination of two or more single lenses designed to operate as a unit.

Light beam.—A bundle of light rays having a cross-section of appreciable size.

Light ray.—A beam of light of inappreciable cross-section.

Location.—A place, other than a studio, selected for taking motion picture scenes.

Loud speaker.—An electroacoustical instrument designed to radiate acoustic power, actuated by power from an electrical system.

Lumen.—The unit of luminous flux. It is equal to the flux contained within a unit solid angle, emanating from a uniform point-source having an intensity of one international candle.

Luminosity curve (*of a source of light*).—A curve showing, wavelength by wavelength, the product of the radiant flux and the visibility.

Luminous efficiency (*of a light source*).—The ratio of the luminous flux (in lumens) to the radiant flux (in watts).

Luminous flux.—The rate of flow of radiant energy evaluated in terms of the luminous sensation it produces. The unit of luminous flux is the lumen.

Luminous intensity.—The luminous intensity of a source of light in a given direction is the solid angular density of the luminous flux emitted by the source in the direction considered, when the flux may be considered to have emanated from a point. The unit of luminous intensity is the candle.

Magazine valve.—The opening in a film magazine designed to prevent the entrance of flames or light.

Masks.—Opaque plates of various sizes and shapes used in motion picture apparatus to limit the effective area of the image.

Matte.—A mask constructed of sheet metal or other opaque material, having an opening of any desired shape, and which is placed in

front of the film in a motion picture mechanism for the purpose of blocking out definite portions of the picture.

Micro- (prefix to units of measurement).—The millionth part of, as in *micro*farad, *micro*ampere, *etc.*

Micron.—The thousandth part of a millimeter.

Microphone.—An electroacoustic instrument designed to convert acoustical waves into electrical waves.

Microphone amplifier.—The first unit in the amplification chain, usually placed close to the microphone.

Mil.—The one-thousandth part of an inch.

Milli (prefix).—The thousandth part of, as in *milli*meter, *milli*volt, *etc.*

Mixer.—An assembly of volume controls and circuits used for combining and regulating the input signals from several sources, such as from several microphones or from several re-recording machines.

Modulation (electrical).—The variation of amplitude or frequency of an alternating current in accordance with the amplitude of a second alternating current or complex wave superimposed upon it. As used in sound recording practice, the superposition of an alternating current on a direct current.

Monitor (verb).—To observe the character and control the volume of sound during recording or reproduction.

Motion picture.—The representation of an object by the rapid presentation to the eye of a series of pictures showing the object at successive intervals of time.

Motion picture projector.—A device for projecting motion pictures.

Moving period.—The fraction of the picture cycle during which the film at the aperture of an intermittent motion picture camera or projector is in motion.

Negative.—Processed photographic material in which the values of light and shade existing in the original object are reversed.

Negative stock.—Light-sensitive film intended for use in motion picture cameras.

Network.—A more or less extensive and definitely arranged group of conductors of electric currents. These may be pure resistors, inductors, capacitors, or various combinations of the three.

Nitrate film.—Film, the base of which is composed mainly of cellulose nitrate.

Objective.—The simple or compound lens nearest an object of which it forms an image.

Observation port.—An opening in the wall of a projector room through which the projectionist observes the screen.

Ohm.—The practical unit of resistance, represented by the resistance offered to an unvarying current by a column of mercury at a temperature of zero degrees Centigrade and of mass 14.452 g., of a constant cross-sectional area and having a length of 106.3 cm. Also, in a-c. circuits, the unit of impedance.

Opacity.—The ratio of the amount of light incident upon a material to the amount transmitted by it; the reciprocal of transparency.

Optical axis.—In a simple lens, the line joining the centers of curvature of the two refracting surfaces; in a centered optical system, the line through the center of curvature of all the refracting surfaces.

Optical wedge.—A device in which the optical density varies progressively from a minimum at one end to a maximum at the other.

Orthochromatic emulsion.—A photographic emulsion which is sensitive to yellow and green light as well as to radiation of shorter wavelengths.

Orthochromatic photography.—Photography which, although in black and white (or monochrome), faithfully represents the visual brightness of the various areas of the subject.

Oscillograph.—A device for photographing or projecting the waveform of electric currents or voltages upon a screen or sensitized surface.

Overloading.—In general, the application to a device of a signal of greater strength than that for which it was designed.

Overshooting.—In general, the momentary excursion of an indicator beyond its final position, such as the overshooting of the pointer of an insufficiently damped voltmeter when the potential is first applied. By extension, this term is sometimes used in connection with the variable width method of recording sound to indicate a momentary excursion of the light beam beyond the limits of the sound track.

Pan.—A contraction of "panorama." Also used as a contraction for "panchromatic."

Panchromatic.—Applied to emulsions that are sensitive to the entire visible spectrum.

Phase.—In uniform circular motion, simple harmonic motion or periodic changes of any magnitude that take place in accordance with simple harmonic law (as sound vibrations, alternating electric currents, *etc.*), the point or stage in the period to which the rotation, oscillation, or variation has advanced, considered in its relation to a reference position or assumed instant of starting.

Pick-up.—A device or system for transforming light, mechanical or acoustical energy into electrical energy.

Photoelectric cell.—A cell containing two electrodes, one of which is a photo-sensitive surface, in which electrons will flow between the electrodes when the sensitive surface is illuminated and an external potential is applied, making the sensitive surface negative with respect to the other electrodes.

Photoelectric effect.—An emission of electrons resulting from the action of light.

Photographic efficiency.—The luminous efficiency (of a light source) is evaluated visually by the number of lumens radiated per watt of energy input. The *photographic efficiency* of a source is the corresponding quantity measured photographically. In the absence of any photographic unit corresponding to the lumen, it is customary to assume the photographic efficiency equal to the luminous efficiency for a source of white light such as mean noon sunlight. The relative photographic efficiency for any source is then specified in relation to a source of white light.

Photometry.—The science of measuring light. The four fundamental photometric quantities are *luminous flux, luminous intensity* (of a point source), *brightness* (of an extended surface), and *illumination* of a surface.

Photoplay.—A story in motion pictures.

Picture-cycle.—The entire series of mechanical operations which takes place between the instant when a given frame of a motion picture film is at a particular point in its path through the projector or camera, and the instant when the next frame arrives at this point.

Positive.—Processed photographic material in which the values of light and shade are similar to those in the original object. A positive may be printed from a negative or may be made directly by a reversal process.

Positive stock.—Light-sensitive film designed for use in making motion picture positive prints.

Pre-release.—A picture not yet released for showing to the general public.

Principal plane.—Either of two conjugate planes perpendicular to the axis of an optical system in which the magnification is unity and positive. The *anti-principal* planes are similar conjugate planes in which the magnification is unity and negative (that is, resulting in an inverted image).

Principal points.—The points in a lens where either principal plane is intersected by the axis of the system.

Print.—A positive produced by a printing process, either photographic or mechanical.

Producer.—An individual or organization engaged in the business of producing motion pictures.

Projectionist.—A person skilled in the art of projecting motion pictures.

Projection distance.—The distance from the projection lens to the screen upon which the image is in focus; commonly termed "throw."

Projector lens.—In a projector, the lens that forms an image of the film or lantern slide on the screen.

Projection period.—That part of the picture-cycle during which a single picture on the film is being projected.

Projection room.—A small auditorium in which motion pictures are viewed.

Projector room.—A room in which motion picture or other projection equipment is located.

Props (contraction of "properties").—Objects used as accessories in a play.

Quality (of luminous flux).—That property of luminous flux determined by its spectral composition.

Q factor.—The ratio of specular to diffuse density. Owing to the scattering of light by photographic emulsions, the value of Q is greater than unity (usually about 1.3). Specular density is approached in practice in projection printing; diffuse density, in contact printing.

Radian.—The angle at the vertex of a sector whose arc is equal in length to the radius of the circle. A radian is equivalent to $360/2\pi$ ($=57.3$) degrees.

Reactance.—That property of passive electric circuit elements which influences, without loss of power, the value of the alternating current flowing in the circuit.

Reactance, inductive.—Reactance due to the presence of inductors in an electric circuit.

Reactance, capacitive.—Reactance due to the presence of capacitors in an electric circuit.

Reciprocity law.—A law discovered by Bunsen and Roscoe, which holds approximately for many photochemical reactions. According to this law, the effect of radiation on a photographic material is

proportional to the product of the intensity of the illumination and the time of exposure. (Negative materials usually obey this law more closely than positive materials.)

Recording channel.—A complete system of amplifying and control equipment, from the microphone to the film or disk used in making a sound record.

Recording drum.—In the sound recorder, a drum over which the film passes during exposure.

Recordist.—In commercial practice, the operator of a sound recorder.

Reel.—(*a*) The flanged spool upon which film is wound. (*b*) The quantity of film that can be wound on such a spool, usually about 1000 feet.

Reflection factor (*of a surface*).—The ratio of the flux reflected by the surface to the flux incident upon it. The reflection from a surface may be regular, diffuse, or mixed. In regular reflection, the flux is reflected at an angle of reflection equal to the angle of incidence. In diffuse reflection the flux is reflected in all directions. In perfectly diffuse reflection, the distribution of the reflected flux is in accordance with Lambert's cosine law. In most practical cases, there is a combination of regular and diffuse reflection.

Reflector arc lamp.—In a motion picture projector, an arc in combination with a reflector, for projecting a light beam through an aperture.

Refraction.—The change in direction of a ray of light that occurs when it falls obliquely upon a surface separating two media through which light travels at different velocities.

Refraction, index of.—The ratio of the velocity of light *in vacuo* (in actual practice, in air) to the velocity of light in a given medium.

Register (*verb*).—(*a*) To indicate an emotional state by action or facial expression. (*b*) To cause to correspond exactly; to adjust so as to secure exact correspondence of position.

Register (*noun*).—Correspondence in position as, for example, of the various monochromatic pictures in color printing.

Relative aperture (*of a lens*).—The ratio of the effective aperture of a lens to its focal length. (See *f/-number*.)

Release.—A finished picture ready for public presentation.

Resistance.—That property of an electric circuit which causes dissipation of energy when an electric current is passed through it. The unit of resistance is the ohm.

Resolving power (optical).—The ability of a lens to form recognizably separate images of adjacent details of an object. It is expressed quantitatively in terms of the maximum number of parallel lines per millimeter that can be distinguished in the image or in terms of the corresponding angle measured in seconds of arc.

Resolving power (photographic).—The ability of an emulsion to distinguish fine detail, usually expressed quantitatively in terms of the maximum number of lines and spaces of equal width, per millimeter of the photographic material, that can be recorded as distinct lines and spaces.

Retake.—The repetition of the act of photographing or recording.

Reverberation.—The persistence of sound due to repeated reflections after the source has been cut off. *Reverberation time* is the time required for the average energy density of the sound, initially in a steady state, to decrease after the source is cut off, to one-millionth of its initial value.

Rheostat.—A variable resistance employed to control or regulate the flow of electric current.

Rushes.—Advance prints; scenes processed immediately after taking, for the assistance of the director.

Safety film.—A motion picture material, a sample of which has a burning time greater than 10 seconds when tested in accordance with the procedure specified by the Underwriters' Laboratory.

Scene.—A division of a story showing continuous action in a given locale or set; usually taken from a single point of view.

Scenario.—A general description of the action of a proposed motion picture. (See *Continuity.*)

Screen.—The surface upon which the picture is projected.

Script (contraction of "manuscript").—(Same as *Continuity.*)

Sensitometry.—In general, the measurement of the sensitivity of a device or instrument; in photography, the measurement of the sensitivity of photographic emulsions, usually by the technic developed by Hurter and Driffield.

Set (contraction of "setting").—The scenic environment in which the action takes place.

Sharpness.—The clearness or distinctness of an image. In a photographic material, sharpness depends on the rate of change of density with distance, at the boundary of the image of a geometrical edge.

Shooting (a scene).—Photographing a scene.

Shot.—Photograph of a scene or action.

Shot, angle.—A scene, inserted in a motion picture, which continues the action of the preceding scene but which is photographed from a different angle.

Shot, close-up.—(See *Close-up.*)

Shot, long.—A scene shot with the camera at a relatively great distance from the set, or with a short-focus lens in order to give the impression of distance.

Shot, medium.—A picture which is shot, or appears to have been shot, at a normal distance from the set—about twelve to eighteen feet.

Shot, stock.—A strip of film carrying photographs of such stock scenes as the Brooklyn Bridge, the Statue of Liberty, the Eiffel Tower, *etc.*, inserted into a picture in order to create atmosphere.

Shoulder.—The overexposure region of the characteristic curve of a photographic emulsion. In this region a linear relation between the density and the common logarithm of the exposure does not exist, and the slope of the curve decreases steadily with increasing exposure.

Shutter.—A moving element, usually rotating, which intercepts the beam of light in a motion picture camera, projector or printer, one or more times during each cycle.

Single picture crank.—Sometimes referred to as a "trick spindle" or a "stop crank;" a crank on a motion picture camera which makes one exposure for each complete revolution.

Slide (stereo slide).—(See *Lantern slide.*)

Slit.—A narrow rectangular aperture in a sound recorder, printer or reproducer.

Slit image.—The image of the slit produced by the objective lens of the sound optical system.

Solid angle.—The ratio of the spherical area intercepted by a cone whose apex is at the center of the sphere, and which includes the solid angle, to the square of the radius of the sphere. (See *Steradian.*)

Sound attachment.—Any mechanism designed as an attachment to standard projectors to permit the reproduction of synchronized sounds and pictures.

Sound head.—The compartment in projection equipment which contains sound reproducing apparatus.

Sound negative.—A negative on which a sound track only is recorded.

Sound recorder.—A device for transforming electrical impulses,

generated by sound waves striking a microphone, into corresponding light variations which are photographed on a film or into mechanical vibrations which are recorded on a disk.

Sound reproducer.—A device for reproducing sound recorded on a film or disk.

Sound track.—The portion of a film on which sound is recorded.

Spectral distribution (of radiation).—The manner in which the energy radiated by the source is distributed with respect to frequency or wavelength.

Spectrophotometry.—A branch of photometry in which the comparison is made wavelength by wavelength.

Spectrum.—An image formed by an optical system containing a refracting prism (or an equivalent element) in which the component radiations are arranged in the order of their wavelengths.

Specular density.—The value of density as measured with substantially collimated light. (See also *Diffuse density* and *Q factor*.)

Speed.—(*a*) (*of a lens*). A value indicative of its light-gathering power, usually expressed in terms of the *f*/-number. The "speed" of a lens is inversely proportional to the square of the *f*/-number. (*b*) (*of an emulsion*). A value indicative of its sensitivity to light, usually expressed in terms of its H & D speed. (*c*) (*of a camera or projector*). The rate at which film travels through the apparatus, usually expressed either in feet per minute or in frames per second.

Splicing.—Joining ends of film by cementing.

Split reel.—A reel of film of two (or more) parts wherein the subject matter of each part is unrelated to the subject matter of the other parts.

Spot.—In projection, the illuminated area on the cooling plate of a motion picture projector. In a motion picture studio or theater, an abbreviation of spotlight.

Sprocket.—A toothed cylinder which engages the perforations in the film.

Stationary period.—That portion of the picture cycle during which the film at the aperture is stationary.

Steradian.—The unit of solid angle.

Still.—A picture without movement; *e. g.*, a picture from a single negative.

Stop.—A diaphragm used to reduce the effective aperture of a lens.

Substandard film.—Film whose width is less than 35 mm.

Subtractive process.—The process for the reproduction of scenes in color, using a restricted number of primary component colors, in which the composite image is produced by passing a single beam of light through a multiplicity of colored images, each of which has a spectral absorption curve differing from that of any of the others.

System, f.—(See *f/number.*)

Take-up (noun).—A mechanism by means of which a film is wound on a reel after it has passed through the projector, camera, printer, *etc.*

Take up (verb).—To wind a film on a reel after it has passed the aperture in motion picture apparatus.

Take-up reel.—The reel on which film is wound after passing the aperture in motion picture apparatus.

Throw.—(See *Projection distance.*)

Time-gamma curve.—A curve in which gamma is plotted against time of development.

Tinting.—Coloring film by dyeing the gelatin of the emulsion. (See *Toning.*)

Toe.—The underexposure region of the H & D curve of a photographic emulsion. Throughout this region, the slope of the curve increases with increasing exposure.

Toning.—Coloring a film by chemical action on the silver image. (See *Tinting.*)

Transmission level.—Transmission level, or simply level, at any point in a system, is the difference, expressed in decibels, between the single frequency power at the point and an arbitrarily chosen reference power. This reference level is usually 0.006 watt.

Transmission unit.—An obsolete designation of the unit now called the decibel.

Transparency.—The ratio of the amount of light transmitted by a material to the amount incident upon it; the reciprocal of opacity.

Traveling matte.—A motion picture film, with an image thereon, which is passed through a motion picture mechanism in contact with the unexposed film for the purpose of preventing local access of light to the latter.

Tri-color ratio.—A series of filter factors which indicate the relative sensitivities of an emulsion to blue, green, and red light under certain specified conditions.

Unmodulated density.—In the variable density method of recording

sound, the density of the sound track obtained when the exposing light is unmodulated.

Vacuum tube.—A device consisting of a number of electrodes contained within a highly evacuated enclosure in which the current in the output circuit is controlled by the potential of one (or more) of its elements.

Variable area sound track.—(See *Variable width sound track.*)

Variable density sound track.—A type of sound track in which the width of the exposed portion is constant, and the amount of light reaching the photoelectric cell is controlled by the transparency of the exposed portion.

Variable width sound track.—A type of sound track in which the density of the exposed portion is constant, and the amount of light reaching the photoelectric cell is controlled by the width of the exposed portion.

Vignette.—To limit a picture area by a border which gradually shades to solid black, usually accomplished by the use of a mask in front of the lens.

Visibility of radiation (of a particular wavelength).—The ratio of the luminous flux (lumens) at the particular wavelength to the corresponding radiant flux (watts).

Volt.—The unit of measure of electromotive force or difference of potential in an electric circuit. It is the electromotive force which, when steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

Volume control.—A variable resistance or other circuit arrangement employed in transmission circuits to control the transmission level.

Volume indicator.—An electrical device used for indicating the power level at a point in a circuit.

Watt.—A unit of power.

Wavelength.—The ratio of the velocity of propagation of a wave to its frequency.

Wax.—A disk, one to two inches thick, of a special wax-like material, on which the first impression of sound is cut in the sound-on-disk process.

Wedge spectrogram.—A spectrogram made by photographing the spectrum through an optical wedge; used to indicate graphically either the spectral sensitivity of emulsions or the spectral absorption of filters.

BANQUET SPEECHES

PRESENTED AT THE FIFTEENTH ANNIVERSARY BANQUET OF THE SOCIETY AT THE NEW OCEAN HOUSE, SWAMPSCOTT, MASS., OCTOBER 7, 1931

President Crabtree: Although most of us are concerned more with the future than with the past, I think it is fitting that on this occasion, the fifteenth anniversary of our Society, we should pause in our hurried pilgrimage toward better motion pictures and pay homage to those engineering pioneers whose efforts have made the motion picture possible.

The motion picture was not invented. It has a long pedigree as have all scientific advances. It moved step by step through the efforts of a long line of workers, including men like Le Prince, Marey, Friese-Greene, Edison, Eastman, Lumière, Jenkins, LeRoy, Paul, Skladanowsky, Lauste, and a host of others.

Through the efforts of members of our Historical Committee, the accomplishments of many of these men have been placed on permanent record and our Society has seen fit to select a few of these pioneers as being worthy of honorary membership in our Society by virtue of having achieved high distinction in the science of motion picture engineering and the allied arts and sciences.

The first award is to Mr. C. Francis Jenkins. For nearly forty years his name has been related intimately with the motion picture industry. Between the years 1892 and 1895 Mr. Jenkins was busy devising both a camera and a projector. Since these early years he has repeatedly shown inventive genius of a high order. Of the numerous technical papers contributed by him to our *Transactions*, those deserving especial mention have dealt with his researches in stereoscopy, non-intermittent mechanisms, high speed photography, and radio vision. In several of these fields, his work has anticipated to a marked extent the trend of scientific endeavor.

But perhaps his most outstanding achievement was the founding of our Society. Let me recount how this was done in his own words:

"Every national organization of the motion picture industry, by whatever name, has had its Committee on Standards. I was first elected to membership on that committee of the Motion Picture Board of Trade. We met once. I was next elected on a similar committee of the present National body, and on call made a trip from Washington to New York to find not a single other member or officer present, with the exception of the Secretary of this Committee who was also Secretary of the National Association, in whose office we were supposed to meet. At my insistence, he telephoned members nearby but without result.

"On the way home that afternoon I fidgeted in my chair, fussed over conditions which made for such fruitless efforts, and determined that I would put my personal standing in the Industry to the risky test of inviting engineers to come to Washington for the purpose of organizing a Society of Motion Picture Engineers, on my own responsibility. I am terrified even now every time I think of the chagrin I would have felt had the call gone unacknowledged.

"But a most gratifying response rewarded my anxious wait on the fateful day, for Mr. Don J. Bell came down from Chicago, Messrs. Willatt and Westcott from Boston; Cromelin, Cannock, Gillett, and Miles from New York. These gentlemen with Mr. Brockett and myself formed a very substantial nucleus indeed. We adopted a constitution and by-laws, and adjourned to meet in New York in October, after incorporation should be completed."

Mr. Jenkins was elected president and presided at the first meeting of our Society which was held at the Hotel Astor, New York City, October 2–3, 1916. The destiny of our Society was guided by him in the next two years when, in the face of an international conflict, the future of a new society was always uncertain. Never for a moment has he relinquished his hopes and interest in our Society.

Unfortunately, Mr. Jenkins is not able to be here, and he has sent this wire:

"Mr. President and Fellow Members, I am greatly disappointed that my recent three months' illness has left me without the strength to attend the Fifteenth Anniversary Banquet of our Society. As I recall the service the Society has rendered to the movie industry, and the growth in membership, I am reminded of the eight pioneers who responded to my invitation to meet me here on July 24, 1916, for the purpose of forming a Society of Motion Picture Engineers. So sound a Society foundation was wrought that few changes have been suggested since, and from this small group of pioneers our Society has grown to an international membership. I feel well warranted in predicting a still greater engineering service as industrial changes follow progress and invention. May I then extend my congratulations and heartiest greetings, in which Mrs. Jenkins joins me, for she hopes to meet the lady attendants in Washington again.

(Signed) C. FRANCIS JENKINS"

In talking with Mr. Jenkins over the telephone, he designated one of his personal friends to receive the certificate of honorary member-

ship, a pioneer and a member of our Society, who was engaged very closely with Mr. Jenkins in his early work—Mr. Oscar B. DePue.

Charles Francis Jenkins was elected to honorary membership in the Society of Motion Picture Engineers, October 4, 1926. It is now my pleasure to present this official record of the honor conferred.

PRESIDENT CRABTREE: The next presentation is to Thomas Alva Edison. We shall hear a recitation of his accomplishments by one of our own members, who has conducted researches for many years into the history of the motion picture—an author of note, and editor of the Motion Picture Herald—Mr. Terry Ramsaye.

MR. TERRY RAMSAYE: It has been my privilege and my honor, several times in the last fifteen years, to speak for, on behalf of, and about Mr. Edison, and I have never done it under what I consider more complicated and emotionally difficult circumstances than tonight. The problem finds me almost as embarrassed as our Dr. Goldsmith said he was, a few years ago, when he found it necessary to sign a license to permit Mr. Edison to manufacture radio sets. That is a key to some of the technological complexities of this business, and the controversial elements of its background.

Tonight is not only an anniversary for the Society of Motion Picture Engineers, but by extraordinary coincidence is also very close to a great anniversary for this industry. Yesterday at noon was the forty-second anniversary of the first demonstration of the Edison Kinetoscope, the machine upon which the commercial development of this art and industry were founded. Mr. Edison came home from a trip to Paris and dashed over to the laboratory in West Orange before he went home, to see this machine which had been finally assembled and put together in his absence. Happily, it worked. And this machine, a little peep-show Kinetoscope, was scattered over the world, and became the germ and seed of the motion picture development that came afterward.

Mr. Crabtree was eminently right, I think, when he said that the motion picture was not invented. I am very much inclined to think that nothing is invented in the terms that the popular mind thinks of invention. But Mr. Edison did bring the motion picture across from that misty background of laboratory endeavor to the margin of the beginning of commercial performance. That was a labor of some two years, beginning in the year 1887. He was conscious of and familiar with a great deal of the work that had gone on in the century

before, including that of some of the gentlemen Mr. Crabtree named, notably Friese-Greene, Le Prince, Paul, and other workers.

The motion picture was just one of Mr. Edison's many important contributions to this technological era. The multiplex telegraph and the dynamo were made commercial machines by Mr. Edison. He gave us the incandescent lamp, the phonograph, and he really in truth went to work on the problem of the motion picture to develop a picture as an accessory to the phonograph. So you see, there was a very early conception of the sound picture.

In the same period in which his motion picture mechanisms were being evolved, some casual experiments developed on what was known for a great many years as the "Edison effect" and which involved, in substance, the principle of the radio valve which has finally come to be married to the film and relate itself to the motion picture, in sound.

I once whimsically remarked to Mr. Edison that he invented the electric light so that we could work nights, and then presently he invented the motion picture so that we all had to.

PRESIDENT CRABTREE: Mr. Edison has requested that a dear personal acquaintance of his for many years shall accept the certificate on his behalf—Mr. A. Y. Attwell.

Thomas Alva Edison was elected to honorary membership in the Society of Motion Picture Engineers on April 13, 1928. On behalf of the Society of Motion Picture Engineers I present this the official record of the honor conferred.

PRESIDENT CRABTREE: The next presentation is to George Eastman. Mr. Terry Ramsaye will also give us an account of his accomplishments.

MR. TERRY RAMSAYE: Mr. Eastman's contribution to the motion picture is well near as basic, fundamental, and important as that of all the other contributors combined, because the motion picture had to have a medium. As all you technicians know, the glass plates and paper tapes which were used introduced insuperable obstacles, and nothing could be done about the motion picture until there was something to make it on. And in truth, Mr. Edison's mechanisms were completed before there was anything to run in those mechanisms. It was in August of 1889 that he heard that George Eastman was about to begin the commercial production of a flexible photographic base for what was known as roller photography, leading up to the kodak. So he sent to Rochester one of his employees who made the

first motion picture raw stock purchase, consisting of a strip of film one inch wide and fifty feet long. No precedents were established but he received that roll of film on credit and remitted in postal money order for it on September 2nd the sum of $1.50. That was the beginning of that business. But in supplying the celluloid or nitrocellulose base as a photographic medium, Mr. Eastman really became the weaver of this magic carpet of the motion picture.

This again was not one of those inventions that come like a magician taking a rabbit out of a hat. It was the result of long, tedious years of engineering research. And you will find in the Eastman archives that certainly no later than 1884 Mr. Eastman began his researches leading up to the evolution of what we now call film.

Tonight Mr. Eastman has behind him fifty-three consecutive, uninterrupted years of research—research in the background of this industry. The whole history of the industry has no such parallel of concentrated, consistent endeavor. For a great many years, as every one in the motion picture industry knows and gladly admits, a very large proportion of all the engineering in the motion picture business was done at Rochester, and shipped out in a can. The industry was entirely dependent upon this raw stock.

There is a little story which I do not believe has ever been published of some interest in connection with Mr. Edison and Mr. Eastman. These two men, by the inter-relation of their researches and technological developments, had a tremendous deal to do with each other's conspicuous success. Finally about the year 1925, the motion picture industry decided it probably owed Mr. Edison something and gave him a lunch. Mr. Eastman was among those in attendance at the the luncheon. Both of them are very prompt and precise, orderly men. They arrived on time. No one else did. They were both checking their coats at the Ritz Carlton Hotel at the same time, and there was no sign of recognition between them. So it was suggested to Mr. Blair, who accompanied Mr. Eastman, that it would be well for these gentlemen to become acquainted. They were introduced then, in 1925, and Mr. Edison looked at Mr. Eastman and said, "You are the film man, aren't you?"

Eastman said, "Yes. I have heard quite a bit about you, too."

"So?" said Edison.

"Yes—along, I think, in '85, I bought a dynamo from you."

"Was it any good?"

"Well," said Eastman, "anyway, it still works."

And Mr. Edison remarked, "As a matter of fact, I think your film is pretty good, too."

PRESIDENT CRABTREE: When I asked Mr. Eastman to designate some one to receive the certificate on his behalf, because his health would not permit him to attend this meeting, this is what he said: "I cannot think of anyone more appropriate to receive the certificate for me than yourself."

It is a pleasure for me to accept the certificate on behalf of Mr. Eastman. He will appreciate it highly and give it a prominent place in his study. He has always been very interested in the welfare of our Society, and manifested that interest in a practical way by encouraging his employees and executives to work on behalf of the Society.

Mr. Eastman has also been passionately interested for many, many years in fundamental scientific research. I think I mentioned previously that I had taken up the matter of the establishment of research fellowships with two of the eastern universities who have intimated their willingness to establish these fellowships if the necessary funds were forthcoming. I approached Mr. Eastman to see if he would be willing to provide the necessary funds for one of these fellowships, and he advises, "I am willing to contribute an amount not exceeding $1500 for the purpose of establishing a Society of Motion Picture Engineers' fellowship in one of the universities, designated by your Board of Governors."

I hope this generous donation of Mr. Eastman will be emulated by many other persons in the industry.

The next presentation is to Frederic E. Ives. His accomplishments will be recited by the Chairman of our Historical Committee—Carl Louis Gregory.

MR. CARL L. GREGORY: Frederic E. Ives was born February 15, 1856, in the little village of Litchfield, Conn. At the early age of eleven years, his father died, and he was compelled to leave school and help support his mother and four younger brothers and sisters. He became a printer's devil in the office of the Litchfield *Enquirer*. It is probable that his work as a printer formed, to a great extent, a substitute for the further schooling which he was unable to obtain. Even with the arduous work of from twelve to fourteen hours daily, in the printer's office, he nevertheless found time to devote to experiments in photography. That was in the old days when they knew nothing of film and had to make their own plates. And at the early age of

about sixteen he made his own first camera from an old cigar box and an old pair of spectacles. He made pictures with that.

At seventeen, he worked as a photographic gallery operator with a distant relative, and shortly afterward took charge of the photographic laboratory at Cornell University, after a battle with the authorities, because they were appalled at his seeming youth. But he made good.

In the days during this period of his work, as he attained his legal age, he invented the photoengraving process which later gave to the world a great profusion of photo-mechanically illustrated books, magazines, and papers.

From those early days, which I have so briefly and so inadequately portrayed, the life of Frederic E. Ives was like a fairy tale in the wonderland of science. The Franklin Institute of Philadelphia presented him with a medal for his work in color production. He has taken out more than seventy patents in the course of his busy life, many of which have now come into the public domain and form the basis for a great part of the present-day achievements in projection, in black and white, and in color reproduction, and in color cinematography. Mr. President, I have the honor to present to you the name of Frederic E. Ives for suitable honorary recognition by our Society.

PRESIDENT CRABTREE: Frederic E. Ives, you were elected to honorary membership in the Society of Motion Picture Engineers, April 13, 1928. It is a pleasure to present you this suitable recognition of the honor conferred; and I do it with a very personal regard for your achievements in the field of motion picture engineering, because it so happens that I have conducted researches along the lines of color photography, and in many cases I have put in applications for patents; but in a large percentage of the cases they were returned with the notation at the bottom, "anticipated by Ives."

The next presentation is to Louis Lumière. His accomplishments will be recited by a member of our Historical Committee —Mr. Glenn E. Matthews.

MR. GLENN E. MATTHEWS: In the year 1880, Antoine Lumière started a modest business in the manufacture of photographic plates in the Montplaisir quarter of Lyons, France. The business flourished and his two sons, Louis and August, became associated with their father in 1883.

As indicated by his work, Louis has been more interested apparently in mechanical and chemical questions related to photography, whereas August has been concerned more with the human side and has published many papers related to medical and biological subjects. Louis has published more than three hundred scientific papers since the first one (published jointly with his brother) appeared in 1887. A keen, untiring interest in research in all branches of photography and cinematography has been the keynote of his life.

His early interest in motion picture photography was concerned both with synthesis as well as an analysis of motion, whereas many of his contemporaries were interested chiefly with the latter subject. About the year 1894, a working model of a camera and projector was demonstrated before a group of intimates at the Lumière plant in Lyons. The first public showing took place on March 22, 1895, at a conference on the photographic industry of the Society for the Encouragement of National Industry. The second showing occurred at the Congress of the National Union of Photographic Societies of France held at Lyons, June 10, 1895. It is of interest that a picture made of an astronomer, Jansen, on one morning during the convention was shown the same day at the evening banquet. The first public showing, for which admission charges were made, took place in the Grand Café, Paris, December 25, 1895. Exhibitions were given with the Lumière Cinematograph in London, at the Royal Polytechnic Institute, February 20, 1896.

Not content to rest on the laurels of a glorious four decades of effort in cinematography, color photography, photographic chemistry, and other fundamental fields of photographic research, this man toils on, a living example to us all of an unflagging devotion to a great cause. His life work will always be an inspiration to every worker in photography.

PRESIDENT CRABTREE: The French Consul at Boston has graciously consented to accept the certificate on behalf of Mr. Lumière—Mr. J. C. Joseph Flamand.

Louis Lumière was elected to honorary membership in the Society of Motion Picture Engineers, April 4, 1923. It is a pleasure to present now this official record of the honor conferred.

MR. J. C. JOSEPH FLAMAND: Mr. President, Ladies, and Gentlemen: On behalf of Mr. Lumière, I accept this certificate of his appointment as an honorary member of your Society. As the French

Consul, I wish to express the privilege that I feel in telling you of the appreciation that France will have, of the honor you have bestowed on one of her children. Thank you.

PRESIDENT CRABTREE: The next presentation is to Eugene Augustin Lauste. His accomplishments will be recited by another member of the Historical Committee—Mr. Merritt Crawford.

MR. MERRITT CRAWFORD: Eugene Augustin Lauste occupies a distinctive niche in the motion picture Hall of Fame because he contributed to an important extent to the inventions of two eras—the silent and the sound picture.

He helped to make the silent picture possible by his invention of a number of fundamental mechanical devices, and aided in developing the mechanics and processes, which made practicable the addition of synchronized sound to the animated scene upon the same film.

Mr. Lauste was employed by Mr. Edison from 1886 to 1892, and was an assistant of Laurie Dickson, Mr. Edison's chief of staff, in the experiments which led to the invention of the Kinetoscope. In 1894 he became associated with Major Woodville Latham, who was at that time interested in step-photography. For him Mr. Lauste designed and constructed the first wide film projector, the eidoloscope, and numerous other cameras and projectors.

In 1896 Mr. Lauste joined the American Biograph Company, and remained with them several years, much of the time in charge of their laboratory and experimental plant near Paris, France. But his chief claim to fame in film history will doubtless eventually rest upon his work in the field of the sound film and its processes. In 1888 Mr. Lauste read an account of the invention of Alexander Graham Bell's photophone, and its successful transmission of sound by means of radiant energy. It occurred to him that the sound waves might be recorded, photographed, and reproduced by means of a light-sensitive cell, in the same manner.

It was his idea at first to record the sound waves photographically upon a ribbon or strip of bromide paper and to reproduce them using a mirror and reflected light. When he saw Eastman's film at the Edison laboratory later, however, he knew that this phase of his problem need give him no further concern.

His other activities, however, kept him from pursuing his experiments actively along this line until the year 1900. Then he found time to make his first "light gate" of the grate type.

In 1904 Mr. Lauste completed his first experimental apparatus for recording sound, and in 1906, with two others, applied at the British Patent Office for a patent described as "a new and improved method of and means for simultaneously recording and reproducing movements and sounds."

To sketch, even briefly, Mr. Lauste's later experiments is, of course, impossible here tonight. The exhibit of his early apparatus at this Convention tells it better, perhaps, than any description could. It is sufficient, therefore, to record that in 1910 Mr. Lauste first successfully photographed sound and scene on the same film and between that date and the outbreak of the War in 1914 photographed many thousands of feet of sound pictures.

His inventions needed only the amplification developed by modern sound engineering skill, to make his sound pictures commercially possible, and he was working on this phase of his problem when interrupted by the War.

As the first man to photograph sound and scene synchronously upon the same film, Mr. Lauste occupies a unique place in motion picture history. The importance of his researches and early experiments, already recognized, will become increasingly apparent with the passing of the years.

Mr. President, I have the honor to present the name of Eugene Augustin Lauste for formal honorary recognition by the Society of Motion Picture Engineers.

PRESIDENT CRABTREE: Eugene Augustin Lauste, on behalf of the Society of Motion Picture Engineers, it is a pleasure to present to you this recognition of your outstanding contribution in the field of motion picture engineering.

PRESIDENT CRABTREE: The next presentation is to Jean Acme LeRoy, whose achievements will likewise be recited by Mr. Merritt Crawford.

MR. MERRITT CRAWFORD: On the morning of February 5, 1894, a group of persons, about twenty-five in number, gathered in Herbert Riley's Optical Shop, 16 Beekman Street, New York, to witness the demonstration of a new device. It was a motion picture projector which had been built by Jean Acme LeRoy, a commercial photographer and experimenter residing in New York. Two kinetoscope films, each about forty feet long, were projected on a screen for the

audience of whom several are still living, who have testified to seeing this notable demonstration.

LeRoy had been experimenting with many devices related to photography as early as 1873, and had even succeeded several years previous to 1894 in producing a semblance of motion with a series of still camera studies on glass plates taken of posed dancers.

His first projector, built in 1893, was designed to use unperforated film. It was not successful, but it encouraged him. When, later, he saw the Edison Kinetoscope with its perforated film, he began work on the machine which was shown at the Riley Optical Shop. The device contained many of the mechanical parts of the present-day projectors, including an intermittent movement, take-up and feed sprockets, and a film gate.

With this projector, LeRoy gave exhibitions for three years whenever he could get engagements. He may properly be described as the world's first motion picture showman.

LeRoy's claim to pioneer fame rests chiefly on his having designed the first motion picture projector with which commercial shows were given for public entertainment. On this basis he is entitled to recognition as a pioneer in cinematography.

Mr. President, I have the honor to present the name of Jean Acme LeRoy for formal honorary recognition by the Society of Motion Picture Engineers.

PRESIDENT CRABTREE: Unfortunately, Mr. LeRoy's physical condition would not permit him to attend this Convention, but he sends a wire extending his regrets and many thanks for the recognition afforded him. Mr. Merritt Crawford has been designated by him to accept the certificate on his behalf.

It is a great pleasure for our Society to present to Jean Acme LeRoy this award for outstanding distinction in motion picture engineering, and will you convey this to him with our best wishes for a speedy recovery?

PRESIDENT CRABTREE: As I pointed out, a large number of individuals have contributed to the development of the motion picture. Many of these have now passed along but our Society has decreed that their names shall be perpetuated by placing them on the Honor Roll of our Society. The first name to be placed on this Honor Roll is that of Louis Aimé Augustin Le Prince.

Between the years 1886 and 1890, he made cameras for taking a

series of pictures in rapid succession upon a long band of light-sensitive material. Samples are in existence of motion pictures taken by him in October, 1888, with a single lens camera at ten to twelve images per second. His single lens camera is stored in the Science Museum, London. Le Prince also devised a projector using an arc lamp for projecting his pictures, as well as spools for development, permitting processing of a long length of film in a small tray.

We have with us this evening the daughter of this outstanding pioneer. She has brought along with her a number of the photographs of the apparatus devised by her father, and perhaps she will say a few words to us on his behalf.

MISS G. MARIE LE PRINCE: Mr. President and Members of the Society: I wish to thank you for the honor to the memory of my father, and especially as a society of engineers, because you will understand the difficulties of a pioneer inventor who had only a home laboratory, and could yet produce inventions which are something like the modern moving picture machines.

Also, I am grateful that this Society is an international society, because I think, as my father often said, that the motion picture would bring all nations closer together and make them more friendly and that in the end, the motion picture would prevent wars.

PRESIDENT CRABTREE: The second name to be placed on our Honor Roll is that of William Friese-Greene. From the time of his first interest in making a device to record a series of images in rapid succession in 1882 to the year of his death in 1921, Friese-Greene experimented with subjects related to cinematography. In January, 1888, he made a series of pictures using a transparent paper band in conjunction with toothed sprockets. Toward the end of that year he secured some nitro-cellulose "dope" and made film support upon which he coated a light-sensitive emulsion. The edges of the film were perforated by running it over sprockets with sharp pin points. The evidence obtained from an examination of the early inventions of this man stamp him as one of the great pioneers in the motion picture field. Besides his patents in ordinary cinematography, the first British patent in color cinematography was granted to him in 1898.

I have a telegram from his son, Mr. Claude Friese-Greene, which says: "My best wishes for a happy evening, in coupling my father's name with motion picture pioneers. May I say that he would wish to congratulate you all on the technical improvements achieved."

I had hoped that I would be able to present to you this evening the man who was the cameraman, the director, and the actual projectionist of that picture, *The Great Train Robbery,* which we saw on Monday evening. Unfortunately, Mr. Porter was called away.

I would like to present another pioneer, who, in 1897, introduced the first motion pictures to India and since then has experimented with mechanical devices to the present day—Mr. A. S. Victor.

I think we should also at this time pay tribute to the following pioneers: William Rock, who, in company with Mr. Wainwright, opened one of the first motion picture theaters of which written and photographic record still exists (this was in July, 1896); Mr. J. Stuart Blackton who, in company with Mr. William Rock, formed the Vitagraph Company of America; Mr. Alfred Smith, who was a partner in forming the Vitagraph Company of America in 1897; Mr. William Reed, who had charge of the Edison peep-hole Kinetoscopes until the spring of 1896, when he was employed by Messrs. Rock and Wainwright as projectionist; he became a projectionist in their theater in 1896 and has been a projectionist continuously since that time until quite recently; Sigismund Lubin, who was president of the Lubin Film Manufacturing Company, one of the early producing organizations and projector manufacturers; Nicholas Power, one of the earliest projector manufacturers, who did more than any other man to effect improvements in the projectors of early days.

We have a cable from Max Skladanowsky, an early pioneer in Germany, regretting that he cannot be present and wishing for our historical celebration a very successful outcome.

We have a telegram from Laurie Dickson: "Greatly appreciate invitation. Regret unavoidable absence. Cordial greetings to all co-pioneers. Shall be with you in spirit."

We have also a letter from D. W. Griffith, a pioneer, who regrets that he cannot be present. We have also a telegram from Carl Laemmle: "Heartiest congratulations on your fifteenth anniversary. Regret I cannot be with you at celebration."

We have a cable from Professor Lehmann: "The German Cinematographic Society greets the historical efforts of the Society of Motion Picture Engineers and the honoring of the pioneers of cinematography, whose work in all cultured lands we may thank for the present world-wide significance of cinematography."

We have also a wire from James H. White: "Very deeply regret my inability to accept your kind invitation to the banquet. All my

good wishes to you and members, and may I ask your prayers for the Old Master, Mr. Edison."

A letter from Mr. Georges Méliès, France, reads, "I am very sorry and very much regret, indeed, not to be able to accept your amiable invitation for which I heartily thank you.

"But I rely upon you for telling to the members of your association that I appreciate very much the honor made to me by them and that I wish for them the greatest success, for the good of the motion picture industry."

Telegrams regretting their inability to be present were also received from Colonel W. Selig, Hollywood, Calif., and Robert W. Paul, England.

PRESIDENT CRABTREE: On a similar occasion as this two years ago, in response to a question as to how it felt to be a president-elect, I said that it seemed as though I had ridden down to the bottom of the Grand Canyon and I suddenly found that I had to walk back again. The journey, however, has been a very pleasant one and not as difficult as I had imagined, thanks to the loyal help of the members of the Board of Governors, the various committees, and the members at large.

But there is hard work ahead for our Society. The present problem of the industry is not that there is any immediate need for new tools but that the industry should better know how to use the tools which it now has at its disposal.

One of the most striking facts which a visitor from the East to Hollywood observes is that the quality of sound reproduction in the screening rooms of the studios is better than that which exists in the majority of theaters throughout the country. The inferences from this are two-fold, namely, that the present size of the sound track is adequate for the industry's immediate needs, and that sound reproduction in the theaters has not kept pace with recording in the studios. This is due to several causes including deficiencies in the maintenance of equipment, imperfect release prints, and imperfect projection.

Although a wider sound track, and especially sound tracks on a separate film, will give some improvement in sound quality, their general adoption will be impracticable for some considerable time to come. It, therefore, behooves the industry to pay the greatest attention to details so as to get the utmost from the sound track which is

at present available. It is possible to get better sound by means of higher quality reproducing equipment, such as the recording machines available for studio work, but much improvement could be obtained by meticulous attention to details with present equipment.

Demonstrations using hill and dale cellulose acetate disk records and improved reproducing equipment including duplicate horns have revealed that it is now possible to reproduce music which goes one octave higher than is possible with present theater equipment, and this addition imparts to the reproduction a striking degree of naturalness.

Although I do not predict an immediate return to disk recording by producers, this epoch-making advance in sound reproduction will, undoubtedly, serve as a stimulus to improvement in the reproduction of sound photographically.

In many cases imperfect maintenance and operation may be attributed to the fact that the projectionist is not always kept on his toes by virtue of his isolation. Even the most aggressive surgeons and professional men attend clinics at least once a year in order to keep in touch with the latest developments. It is the duty of the projectionist organizations to establish corresponding seminars in key cities, which projectionists from all theaters should be compelled to attend, substitutes being supplied to their own theaters during their absence. Also, more projectionists should be permitted to attend our conventions. The resulting stimulus and acquaintance with men who are constantly striving to improve the motion picture could not help but result in a marked improvement of the picture and sound quality in the theater.

There is also much room for improvement in theater showmanship. The motion picture theater of today is too much of a machine—it lacks soul and personality. More atmosphere and glamour could be created by individuality in the technical presentation of the picture. Neither sound nor picture is a perfect replica of nature but after four years of evolution the sound, as reproduced at present in conjunction with motion pictures, is more true to nature than the picture which lacks color and depth. The reproduction of speech is quite satisfactory but the reproducible volume and frequency range is inadequate to simulate orchestral music. The patron, however, does not realize these shortcomings when he is placed in the mood of willingness to believe by means of suitable atmosphere.

The problem of the quality of the release print is also a very urgent

one. The difficulty involved is to produce release prints which are replicas of the best print which the original picture and sound negatives are capable of giving. To an impartial observer it would appear that the quality of the sound in the case of release prints, in many cases, is not equal to that of the first print produced in Hollywood. A second striking observation to the Hollywood visitor is the recent great improvement in laboratory equipment and the meticulous care with which the equipment is constructed and maintained.

But the quality of the product largely reflects the quality of the man-power which produces it. In Hollywood there is a spirit of coöperation and friendly rivalry to produce the best motion pictures possible. It is highly important that the eastern technicians cooperate to the utmost not only with themselves but with the technicians in Hollywood; otherwise, I predict that Hollywood will not only be the center of production but of laboratory processing as well.

But what will be the next outstanding technical development of the industry? Color is the only immediately available variant from the prevailing black-and-white picture. It has little box-office value at present because the public thinks of colored pictures in terms of some of the wretched ones which it has already seen. You have seen some excellent examples of colored motion pictures during our Convention which were adequately sharply defined, and when similar films are generally available, the public will undoubtedly register its appreciation.

The next innovation will probably consist of the imparting of depth both to picture and sound. Demonstrations at our Convention have indicated that the possibility of securing stereoscopic motion pictures without the use of auxiliary devices is not as remote as we had previously supposed, while in the case of many of the scenes of the color pictures referred to above, the color imparted a surprising degree of semblance of depth to the picture.

It would also be possible to secure startlingly entertaining and amusing effects by the use of devices which would permit binaural reproduction, whereby an independent sound record is transmitted to each ear. This would necessitate the use of multiple sound tracks on the film and independent reproducing channels leading to ear phones which the audience would undoubtedly tolerate for short presentations. The effect of a person whispering in the ear can be simulated with startling fidelity and such effects, judiciously combined

with suitable picture material, would provide some of the necessary novelty for the motion picture presentation which the public is always anticipating.

Another development of the future during the summer months will undoubtedly be the outdoor theater. The public is outdoor-minded, and open air symphonies, outdoor plays, and outdoor events of every description have never been better attended. Rear screen projection has been developed to a point where adequate screen brightness is easily attained while the engineer could undoubtedly provide effective means to destroy intruding flies and insects.

It is questionable whether the 16-mm. film in the home will ever be a serious competitor of the motion picture theater as a means of entertainment. In the home, man is inherently too lazy to set up and operate a projection machine to exhibit pictures other than those of his own making in which his guests are usually not interested.

The spectre of depression has been relatively kind to the motion picture industry. Present box-office receipts are only 10 per cent below those of last year but the quality of the motion picture was never better than it is today. In order for business to improve, we must give better and better values. If the public knows anything at all, it knows values in entertainment. It was Emerson who said, "Let a man preach a better sermon, write a better book, or build a better mouse trap than his neighbor—though he build his house in the woods—the world will make a path to his door," and his words are equally applicable to motion pictures.

Better business is a question of each one doing more and better work than ever before—more intensive research work—the making of better tools—doing better work with existing tools—better stories—better direction—better acting—better film stocks—better camera work—better laboratory work—and better projection. So long as we continue to provide better entertainment, the continued success of this motion picture business is assured.

PRESIDENT CRABTREE: My only remaining duty is to introduce to you our President-Elect. He is a big man with a big concern, and I know he is going to do big things for our Society—Dr. Alfred N. Goldsmith, Vice-President of the Radio Corporation of America.

DR. A. N. GOLDSMITH: The great honor which the Society of Motion Picture Engineers has conferred upon me, in granting me the opportunity to aid in its further upbuilding, is one which is at once

most encouraging and a challenge to put forth my best effort on behalf of the membership. If I may speak for the officers of the Society for the coming year, it would be to express our appreciation of so fine an opportunity and our thorough understanding that whatever may be accomplished during the year will of necessity rest upon the firm foundation of splendid achievement of those who have in the past so capably conducted the affairs of the Society. If their wise guidance and advice will still remain at the disposal of the Board of Governors and the officers of the Society, as we are convinced it will, there can be little doubt that the Society will continue its healthy and constructive career.

May I also pay tribute to those courageous pioneers whom we have honored this evening? Their determination permitted them to conquer physical obstacles and public scepticism. I am reminded of a pertinent episode:

About a century ago a far-sighted New England gentleman applied for leave to debate the possibility of steam railroads in the village schoolhouse. The skeptical Board of Selectmen answered him in the following uncompromising language: "You are welcome to the use of the school house to debate all proper questions in, but such things as railroads and telegraphs are impossibilities and rank infidelity. There is nothing in the word of God about them. If God had designed that His intelligent creatures should travel at the frightful speed of fifteen miles an hour by steam He would clearly have foretold it through His holy prophets. It is a device of Satan to lead immortal souls down to hell." And so it was with motion pictures in the early days. Few had faith and still fewer the ability to carry forward the art. Tonight we have recognized some of those brave and clear-visioned men who battled with the unknown in those trying times.

May I also express my belief that the S. M. P. E. is destined to be the standard bearer and representative organization of the motion picture engineers.

Through this body, the motion picture industry is rapidly learning of the importance of the engineer. For the first time artists and engineers are working together, as they should, both of them creative in spirit, dignified in their activities, professional in their outlook, and both troubled by similar problems. The staffs of operating technicians in the studios and theaters are also coming closer each day to the engineer. Each group can be of greater help to the other. The engineer can explain the reason for the equipment design to the

technician, can bring out the fine points of its utilization, and can anticipate and cure the troubles which may arise in its daily use. The technician, on the other hand, can present to the engineer a multitude of practical problems of daily routine which require ingenuity for their engineering solution. He can make most valuable criticisms and suggestions. These groups should and must come closer together, and it is to be hoped that the Society of Motion Picture Engineers will contact directly with the technicians of the industry with this aim in view. I shall not touch further on the tasks of the Society in the immediate future, particularly since they have been so clearly outlined to you in President Crabtree's opening address.

I wish only to emphasize, in more general terms, that we should all work together in this Society to bring more science into the field of motion pictures and, by this means, greater effectiveness, increased acceptance of the product by the public, and a continually higher status of the motion picture industries. We have this privilege of working for the growth of that agency, science, which is so well described in the inscription on the dome of the building of the National Academy of Sciences in Washington, where it is stated: "To science, pilot of industry, conqueror of disease, multiplier of the harvest, explorer of the universe, revealer of nature's law, eternal guide to truth." Gentlemen, with this aim in view, your officers will endeavor to carry forward the work of their able predecessors during the coming year.

MR. L. C. PORTER: Mr. President, Ladies and Gentlemen: Some of you who have had the patience to sit in at our meetings have probably gathered the idea that the Board of Governors' meetings have not always been in agreement. We have had many and long arguments. There is, however, one point on which the Board is entirely unanimous, and that is that our President, John Crabtree, has made an outstanding executive, and given unstintingly of his time and his interest, frequently at the sacrifice of personal pleasures, in the promotion of the welfare of the Society. President Crabtree has been on the Board for a good many years. He was on the Board before he became President. And at the first Board meeting which he attended, he made the statement that he felt, in the interests of economy, it would be desirable to remove the names of the officers from our letter-heads, leaving only the name of the Society. At every single Board Meeting since then President Crabtree has pleaded long

and fluently in that cause. At our last Board meeting, Sunday night, the Board finally moved to remove the names from the stationery. Our Board has, therefore, prepared some resolutions for President Crabtree, and in order that he may have a fitting souvenir of his victory, we have prepared those resolutions on the last sheets of stationery having the officers' names at the top.

Swampscott, Mass.
October 7, 1931

President Crabtree:

We, the undersigned members of the Board of Governors of the Society of Motion Picture Engineers on this the fifteenth anniversary of the founding of our Society, wish to express our sincere appreciation of our retiring President, John I. Crabtree.

We feel that the recent administration, due largely to the courage and foresight of President Crabtree in initiating many original activities to promote the progress and welfare of the Society and in carrying to successful conclusion various things for which solid foundations had already been laid, has firmly established our Society as the foremost technical organization in the world.

Among the major events which have occurred under President Crabtree's leadership we are proud to record:

(1) The delegation of the Society's administrative details to a professional editor-manager.
(2) The establishment of headquarter offices in New York City.
(3) The expansion of our *Transactions* into a flourishing JOURNAL.
(4) The foundation of three additional sections of the Society.
(5) Revision of our Constitution and By-Laws.
(6) The establishment of sustaining memberships.
(7) The initiation of a research fellowship in motion picture engineering at one of the nation's foremost seats of learning.
(8) The inauguration of an honor roll to commemorate the work of the great pioneers who have passed on.

We are further proud and glad to assert that President Crabtree has proved a sympathetic leader, patient and strong in his conduct of both our general sessions and the Board meetings.

We take this occasion to confess our regret that it becomes necessary for him to relinquish the reins of office. We assure him of our loyal friendship and continued support and we wish him success and prosperity in whatever endeavor he may undertake.

(Signed)

F. C. BADGLEY	W. C. KUNZMANN
HERFORD TYNES COWLING	J. H. KURLANDER
K. C. D. HICKMAN	M. W. PALMER
WILLIAM C. HUBBARD	L. C. PORTER
J. ELLIOTT JENKINS	E. I. SPONABLE

PRESIDENT CRABTREE: Fellow members of the Society, I assure

you I shall greatly cherish this token of esteem from the Board. I want to assure the Board and members that my work on behalf of the Society has by no means come to an end. I am always at your right hand, Dr. Goldsmith, ready at your call.

PRESIDENT-ELECT GOLDSMITH: Thank you, Mr. Crabtree, I greatly appreciate it.

MR. F. H. RICHARDSON: I want to say that I believe every member of this Society would be very glad and very proud to have his name added to that list, as signing that set of resolutions.

ABSTRACTS

Moving-Coil Telephone Receivers and Microphones. E. C. Wente and A. L. Thuras. *J. Acoustical Soc.*, **III**, No. 1, Part 1, July, 1931, p. 44. This paper is concerned primarily with the general principles of design of moving-coil receivers and microphones. There are included circuit diagrams for several systems together with the calculated and experimentally measured response curves of a moving-coil head receiver and a moving-coil transmitter.

In regard to the microphone it "has important practical advantages over the condenser transmitter in that the amplifier may be at some distance from the transmitter without loss in efficiency and in that no polarizing voltage is required. The sensitivity of this transmitter is about 10 db. higher." W. A. M.

Mass Controlled Electrodynamic Microphones. H. F. Olson. *J. Acoustical Soc.*, **III**, No. 1, Part 1, July, 1931, p. 56. A theoretical discussion of a mass controlled electrodynamic microphone is presented. A microphone of this type, which consists of a light corrugated ribbon suspended in a magnetic field and freely accessible to air vibrations, is described. The theoretical response-frequency characteristic to be expected is calculated and compared with the measured characteristic. The response is shown to be substantially uniform between 100 and 5000 cycles. A more detailed account of the application of the ribbon microphone will be found in an article by H. F. Olson, *J. Soc. Mot. Pic. Eng.*, June, 1931. W. A. M.

Microphone Technic in Radio Broadcasting. O. B. Hanson. *J. Acoustical Soc.*, **III**, No. 1, Part 1, July, 1931, p. 81. This paper is especially concerned with the difficult task of picking up action which takes place over a large area, such as symphony orchestra and stage presentation of an opera under conditions where the arrangement of the players cannot be adjusted to be ideal for sound pick-up. In particular is the use of a parabolic reflector discussed. Several specific cases of the usefulness of such a directional pick-up device in actual broadcasting are described. Also response curves of the directional effect at various frequencies are shown. The author believes that the development of a directional pick-up has been a great step forward in microphone technic and he expects to see considerable development in directional microphones in the next few years, which in turn will enable broadcasters to build larger productions and transmit them with even more fidelity than at present. W. A. M.

The Development of the Microphone. H. A. Frederick. *J. Acoustical Soc.*, **III**, No. 1, Part 2, July, 1931. This paper is a presentation of the history of the microphone starting with developments as far back as 1837 and carried through to the present time. During the period immediately following 1875, almost every conceivable type of microphone was tried. Since the magnitude of the electrical output was of more importance than extreme faithfulness of reproduction, the granular carbon type of microphone rapidly came to the front, and extensive work on this type of transmitter led to successive improvement of both these

factors and also in the reliability of the instrument. Since the advent of the vacuum tube amplifier there has been a demand for microphones which would reproduce sounds of widely varying character with extreme fidelity with no restrictions on the level of output except that it should be considerably above the noise level. A number of microphones of this type have been developed and used, perhaps the best known type being the condenser transmitter. Fifty-one references are cited. There are twenty-seven figures, many of which are photographs of various types of microphones which have historical significance. W. A. M.

Some Physical Factors Affecting the Illusion in Sound Motion Pictures. J. P. MAXFIELD. *J. Acoustical Soc.*, **III**, No. 1, Part 1, July, 1931, p. 69. "This paper describes the results of an empirical study of methods of controlling some of the factors available to the engineer in sound recording and photography in such a manner that a pleasing illusion of reality is created in the theater." The author takes cognizance of the fact that an observer, in seeing and hearing a scene, uses two eyes and two ears, whereas in viewing the scene through the medium of a sound picture one is restricted to one eye, namely, the camera lens, and one ear, the microphone. Admitting this basic limitation of sound picture recording, an attempt has been made to make use of all the factors possible to make the sound motion picture of a scene appear as natural as possible to a member of the audience viewing it. A definite position of the microphone is specified as a function of the focal length of the lens being used and the acoustic quality of the set in which the action is being taken. W A. M.

Bibliography of Acoustics of Buildings. F. R. WATSON. *J. Acoustical Soc.*, **III**, No. 1, Part 1, July, 1931, p. 14. In this bibliography an attempt has been made to include all articles concerning the acoustics of buildings from 1920 to 1930 which appeared in scientific and engineering journals together with certain others which were accumulated by the author. The references are divided into three groups, namely, "general," "acoustics of rooms," and "noise insulation." Some four hundred references are listed. W. A. M.

Wide-Film Color Cinematography. *Brit. J. Phot., Color Supp.*, **78,** Sept. 4, 1931, p. 35. The application of color to wide films raises difficulties, since the 56 mm. width involves a wider arrangement of the three films grouped in exposure position in the camera. Three methods of overcoming this difficulty are reviewed here. All are taken from recent patent specifications. Two are based on beam-splitting prisms, and the third uses one bi-pack and one single film at right angles to each other, with a rotating sector mirror to locate the image alternately upon the film surfaces. A. A. C.

Increasing the Usefulness of Theater Sound Equipment. G. S. MITCHELL, *Proj. Eng.*, **3**, September, 1931, p. 11. A description is given of auxiliary sound apparatus for extending the uses of standard equipment in the theater. A microphone for announcements; auxiliary loud speakers for reënforcing the audible parts of stage presentations, or to serve the director in rehearsing stage shows; and broadcasting from the theater are some of the subjects discussed. These additions to equipment can be made from standard parts and are of great service in increasing the effectiveness of the program A. A. C.

Acoustics of a Flexible Space Theater. C. W. MEYER. *Mot. Pict. Proj.*, **4,** September, 1931, p. 12 The article describes a series of analyses conducted to determine the nature and extent of the acoustical treatment which will be re-

quired in the proposed Ukrainian National Theater. The plans include a flexibility never before attempted; they propose a construction of stage and auditorium that may be instantly transformed by means of a central control into a concert hall, opera, multiple stage theater, circus, or convention hall. From analyses of models of all these arrangements it is concluded that excellent acoustical conditions can be secured. A. A. C.

Prevention of Interfering Noises. P. T. SHERIDAN. *Mot. Pict. Herald*, **104**, No. 5, Sec. 2, Aug. 1, 1931, p. 33. This is the second of three articles covering the prevention of noises in reproducing systems in theaters. This article covers noises of an intermittent nature. The sources of this type of noise may be any one or more of the following: run down batteries; corroded or dirty clip contacts on fuses or ferrule type resistors; loose connections throughout the sound system; dirty contacts on faders and volume controls; poor brushes and rough commutators on motor-generator sets. A. A. H.

Acoustical Problems of Sound Picture Engineering. W. A. MCNAIR. *Proc. I. R. E.*, **19**, No. 5, Sept., 1931, p. 1606. The author points out the fact that a great advance in acoustical engineering was necessary in order to control new conditions which have been brought up by sound pictures. The article mentions several problems encountered by the author and discusses one type of acoustical distortion encountered. Numerous curves and formulas give a concise explanation of these problems. A. A. H.

Prevention of Interfering Noises. P. T. SHERIDAN. *Mot. Pict. Herald*, **104**, No. 9, Sec. 2, Aug. 29, 1931, p. 28. This is the last of three articles covering the prevention of interfering noises in theater sound reproducing systems. This article describes and gives suggested remedies for the following steady noises: ground or "rush" noise; a-c. pick-up from power circuits; a-c. light leaks into PE cells; sprocket hole and framing line noise; electrical disturbance due to mechanical vibration. A. A. H.

The Reversal Process. W. RAHTS. *Kinotechnik*, **13**, June 20, 1931, p. 207. The theory and practice of photographic reversal processes are reviewed. Sensitometric curves on Agfa Reversal Film are given to compare the following methods of compensating for variations in the camera exposure: (1) variation in the time of first development in a developer containing a solvent for silver bromide; (2) variation in the second or reversing exposure; (3) bathing in 10 per cent hypo for various times before the second exposure; (4) reduction of the reversed image for various times in potassium permanganate. In the method of varying the second exposure, a sensitometric comparison is given of the effects of using the following bleaching and clearing baths: (1) potassium permanganate, followed by potassium metabisulfite; (2) potassium permanganate, followed by sodium sulfite; (3) potassium bichromate, followed by sodium sulfite. It is stated that (2) and (3) tend to allow re-reversal, and that therefore the controlled second exposure does not permit as wide a choice of bleaching and clearing baths as the controlled first development. Control by bathing in hypo is said not to give clear highlights, and reduction with permanganate is said to give a small range of control. M. W. S.

Improvements for the Motion Picture Camera. F. EULDERINK. *Focus*, **18**, August 15, 1931, p. 471. Favorable notice is given an article appearing in *Der Filmamateur* which suggests a number of features that should be added to the small film camera, presumably for the serious worker. These features are as

follows: (1) interchangeability of regular and telephoto lens; (2) a prism or mirror behind the finder to permit viewing from the side so that pictures can be made without the knowledge of the subject; (3) focusing directly on the film; (4) variable camera speed; (5) an iris diaphragm in front of the lens and a single-turn crank for backing the camera movement for double-exposures; (6) arrangement for fading in and out; (7) a device for shutting off the camera after letting it run for several seconds; (8) a chain support which has the function of a tripod but consists of a chain held under the foot or otherwise; (9) a tripod attachment point on the top of the camera so that it can be supported upside down. C. E. I.

British Separately Mounted Sound Reproducer. *Kinematograph Weekly*, **171**, May 21, 1931, p. 68. In this new type of equipment, the sound-on-film synchronizing parts are mounted on a separate pedestal quite apart from the projector. The sound-head itself is carried on a horizontal adjustable bar attached to the top of the film pedestal. It is claimed that the apparatus is extremely simple to install, and its design is such that no vibration is transmitted to the pedestal from the projector. C. H. S.

British Portable Projector with Sound. *Kinematograph Weekly*, **171**, May 21, 1931, p. 67. Describes a new type portable, sound-on-film, 35-mm. projector with a film capacity of 1000 feet. It is claimed that a 1000-watt lamp gives sufficient illumination for a clear and evenly illuminated 8 feet by 6 feet picture at a distance of from 50 to 60 feet. Cooling is accomplished by means of a fan which is attached to the main shaft of the projector and which forces air through a flexible tube into the heavily ribbed lamp housing. Also, to avoid excessive exposure of the film to the heat rays of the lamp, a novel type of rear shutter has been incorporated, which dispenses the hot air and maintains a low, even temperature.

Advice for the projection of the film in a stationary position for lecture purposes is incorporated. The amplifier is operated on alternating current only. A screen, 5 feet by 4 feet, is incorporated in the set and is withdrawn from the case much as a roll top of a desk, the ends being quickly affixed to a frame. C. H. S.

Apparatus for Panoramic Cinephotography. A. VISBECQ. *Bull. soc. franç. phot.*, **73**, April, 1931, p. 71. The principle of this newly designed camera is that the light rays entering the camera are reflected successively by each of a number of vertically set mirrors fixed on a drum which revolves on a vertical axis. The rays, after being reflected from a mirror, pass into a fixed photographic objective, then onto a vertical slit behind which a standard 35-mm. film moves laterally with a constant linear motion. The film behind the aperture follows the contour of a cylinder whose axis is determined by the focal length of the objective. The mirrors are of a non-oxidizable metal, and the objective in the camera has an ordinary diaphragm which controls the amount of light falling on the aperture. The width of the aperture can be varied so as to permit the different times of exposure. The sprocket carrying the film past the aperture is driven by a direct drive from the drum. For a drum carrying 12 mirrors with an optical system a panoramic range of 60 degrees, the length of the image will be 57 millimeters, taken at 15 frames per second.

The apparatus for projection is constructed almost identical to the camera. Light is focused on the film behind the slit, and as it is only necessary to illuminate a very narrow slit, very high light intensity can be obtained. The image of the slit

is focused by the objective onto the moving mirrors and then to the viewing screen. The inventor makes the following claims: (1) allows the taking of wide screen views; (2) permits continuous movement of the film; (3) economizes light energy in the projector; (4) apparatus is constructed very simply; (5) apparatus can easily be changed over for scanning motion picture films, for television work; (6) although individual frames are 57 millimeters wide, the apparatus is suitable for sound recording as fifteen frames are taken per second, which corresponds to standard practice of twenty-four ordinary frames per second. C. H. S.

The Unique Studio Theater. *Mot. Pict. Herald,* **104,** Sect. 2, August 1, 1931, p. 17. Describes the first of a series of small (turnstile) theaters to be instituted by a theater circuit located in Los Angeles. Front projection is planned, the throw being about 80 feet. The building will occupy a space 30 feet wide by 100 feet long. Novel features of the theater are: automatically changing bulletin frames connected to small loud speakers which will describe the copy; remotely controlled change machines for ticket purchasers; entrance doors operated by photoelectric cells and drinking fountains which are turned on by photoelectric cells. The seating capacity will be 300 and seats will measure 36 inches width back to back instead of the usual 32 or 34 inches. G. E. M.

Selection and Maintenance of Screens. F. M. FALGE. *Mot. Pict. Herald,* **104,** Sect. 2, August 1, 1931, p. 30. Screens are classified into three types: namely, (1) diffusive or matte screens, which direct light in all directions; (2) directive or beaded, which direct light back within a narrow angle to the source; and (3) reflective or metallic, which direct light much as the beaded type. Suggestions are given for choice of screen for various types of houses, and on care and maintenance of screens. Air currents should never be directed through a screen, and the surface should be protected from dirt when not in use. G. E. M.

Photo Sound Analysis. G. J. REID. *Mot. Pict. Herald,* **104,** Sect. 2, August 1, 1931, p. 54. Describes a rapid record oscillograph which mades on paper a photographic record of pure tone or complex frequency from 30 to 6000 cycles. Frequency, pressure, and deviation are recorded in the photographic strip of 35-mm. width. The string of the galvanometer is of duralumin, less than 0.001 inch in diameter, stretched between the poles of an electromagnet and stretched to provide a definite resonance frequency. Three such strings provide means for simultaneously recording data from as many sources. Means for automatically processing the exposed record are provided on the instrument so that the average oscillogram is ready for inspection within 30 seconds after the instrument is started. G. E. M.

The New B. & S. Rear Shutter. F. H. RICHARDSON. *Mot. Pict. Herald,* **104,** Sect. 2, August 1, 1931, p. 62. Two angular air-moving blades are fronted by a flat blade of equal size. The shutter is claimed to perform three operations effectively; namely, (1) to keep the film free from dust and dirt, and to prevent the entrance of air currents into the lamphouse; (2) to reduce the heat at the aperture; (3) to minimize film buckle. G. E. M.

Horizontal Film Inspection Device. F. H. RICHARDSON. *Mot. Pict. Herald,* **104,** Sect. 2, August 1, 1931, p. 65. Describes a film inspecting machine for use in exchanges. It is claimed that the device permits rapid detection of damages to film. Film travels through the machine at a speed of 350 feet per minute. Film is cleaned at the same time, but the device is not intended to renovate dirty film.

When any fault is detected, such as a poor splice, the machine stops automatically.
G. E. M.

Asbestos Screen. G. J. Reid. *Mot. Pict. Herald,* **104,** Sect. 2, August 1, 1931, p. 73. The material of this screen consists of rod-like threads of asbestos, on the surface of which a highly reflecting material has been coated. A uniformly high reflection of light at all viewing angles is claimed for the new product when woven into a reflective surface. Distortion is said to be eliminated. G. E. M.

The Technic of Recording. A. Lovichi. *Technique Cinemat.,* **2,** July, 1931, p. 9. A brief discussion of the reasons for re-recording and a description of an American system for re-recording. J. W. M.

Acoustics and Ventilation of Rooms for the Generation and Reproduction of Sound. IV. *A priori* study of an auditorium. G. Lyon. *Technique Cinemat.,* **2,** March–April, 1931, p. 3. A geometrical treatment of the relation of direct and reflected sound waves from the interior surfaces of auditoriums. J. W. M.

Acoustics and Ventilation of Rooms for the Generation and Reproduction of Sound. V. *A priori* study of an auditorium. G. Lyon. *Technique Cinemat.,* **2,** May, 1931, p. 3. Desirable dimensions are worked out for an auditorium with stage, for the best acoustic results. J. W. M.

Acoustics and Ventilation of Rooms for the Generation and Reproduction of Sound. VI. Placement of the Microphone in a Sound Recording Room. *Technique Cinemat.,* **2,** July, 1931, p. 3. G. Lyon. This discussion centers around the conditions for acoustic efficiency and freedom from reverberation in a room used for recording sound or the like. It treats briefly the cases where there are more or less widely distributed sources. [Abstractor's Note: The treatment is very general and does not include any discussion of the latest methods of adjusting sound reflection values for the sake of greater realism.] C. E. I.

New Kodascope. *Movie Makers,* **6,** August, 1931, p. 442. The recently announced Model K Kodascope is very easy and convenient to operate, since it has simple, straight-line threading and all the operating controls are grouped on a panel for easy accessibility. An added convenience is the outlet for attaching a table or floor lamp, which is then operated by the projector switch. Exceptional screen brilliance is obtained with the direct optical system, large aperture lens, and special 260-watt lamp. The lamp house is readily accessible for replacing bulbs and for cleaning, and is well light-trapped and so efficiently ventilated that it can not overheat. Lenses of varying focal lengths for both black-and-white and for Kodacolor are interchangeable. The projector will operate forward or in reverse, and has a rapid motor-driven rewind. H. P.

Sparton Visionola. *Movie Makers,* **6,** August, 1931, p. 443. A combined home talkie apparatus and radio composed of projector, turntable (operating at either 78 or 33 $^1/_3$ rpm.) pick-up, amplifier, and radio set, is completely housed in the console type of cabinet. The folding screen forms the cover of the cabinet, and in operation is set at a slight tilt for most convenient observation. Since the projector is a horizontal type, the picture is projected to the screen by an ingenious reflector device. Threading is very simple. The projector, turntable, or radio may be used independently if desired. H. P.

Pathe Sound. *Movie Makers,* **6,** August, 1931, p. 446. These combined radio and 9.5-mm. sound movie outfits for the home consist of a superheterodyne radio, projector, and synchronized turntable driven by a speciallv designed motor, and a

professional pick-up. In Model 1, the projector, turntable, and pick-up are contained in a sound-proof housing which is stored in a special compartment in the radio cabinet, but when in use is placed about 12 feet from the radio, before which the screen is mounted on sliding arms. In the Model 2, the above units are contained in two matched cabinets, designed to be placed on opposite sides of the room. A large library of 9.5-mm. sound pictures has been established for supplying subjects. H. P.

"Pan" Speeds Ahead. RUSSELL C. HOLSLAG. *Movie Makers*, **6**, July, 1931, p. 373. The Supersensitive 16-mm. reversal film recently introduced offers new possibilities to the amateur cinematographer. It is twice as fast to daylight and three or four times as fast to artificial light as the older "pan" film. Since the increase in speed is to the red and yellow light, the former disproportionate sensitivity to blue is overcome, so that color filters are less necessary, but at the same time are much easier to use, as the filter factors are greatly reduced. The great latitude insures detail in the shadows as well as in the highlights, while a special backing prevents halation, thus making possible many shots which were formerly impossible. These qualities, coupled with improved sensitivity, make it especially adapted for telephoto work. Interior pictures may be made at night with only a few hundred watts of incandescent lighting, if the available light is intelligently conserved by use of reflectors, light walls, hangings, and light clothing of the subject. It also greatly increases the possibilities for industrial, educational, and medical filming, since the ordinary light equipment may be used, and for cinemicrography, where the light is often weak. H. P.

ABSTRACTS OF RECENT U. S. PATENTS

1,816,039. **Printing Device for Colored Films.** R. BERTHON. Assigned by mesne assignments to Kislyn Corp. July 28, 1931. An electromechanical process for printing reticulated films wherein a projecting lens is interposed between a linearly reticulated film to be copied and a blank copying film. An iron magnetic armature is secured to the lens, which armature is vibrated by an adjacent electromagnet for displacing the optical center of the lens with relation to the network of the film to be copied so that each striation of said network will be spread out, as projected, over a surface equal to an interval of the network. A large number of vibrations per image are impressed upon the armature and lens.

1,816,083. **Rotatable Screen for Three-Color Cinematography.** A. HNATEK. July 28, 1931. A rotatable screen having red, green, and blue sectors thereon is provided for three-color cinematography in which only two of the three-color record images are taken at each exposure. The screen comprises filtering sectors separated by opaque sectors and divided into two concentric annular parts, one annular part having only one of the said three colors in all its sectors, the other annular part comprising the two other colors, which occur separated from one another and in opposite sectors of the annular part. By taking exposures the areas of the colors are inversely proportional to the sensitiveness of the film for the different colors. In projecting a film taken in this manner, the areas of the colors can be the same for all colors. If an auxiliary color is used for projecting purposes, the area (the sector) of such color is much smaller than the area (the sector) of the main colors by which this image is taken.

1,816,106. **Means for Driving Television or Other Apparatus at a Predetermined Speed.** J. L. BAIRD. Assigned to Television, Limited. July 28, 1931. A constant-speed motor such as a fork-controlled phonic wheel is arranged to drive a reversing switch operated at a constant frequency. Direct current is supplied to the switch and by virtue of the periodical reversals, a constant-frequency alternating current is made available. This alternating current is used to drive a synchronous motor, the speed of which is controlled by the frequency of its supply current, so that the speed of this motor is accurately controlled by the speed of the above-mentioned constant-speed motor.

1,816,234. **Projecting Machine.** A. SAPIER. Assigned to Universal Stamping & Mfg. Co. July 28, 1931. The casing of the projector extends around the support which houses the driving motor of the projector and may be adjusted angularly to different positions in a vertical plane for facilitating movement of the projector with respect to the receiving screen. The casing has a hollow cylindrical journal at its base which wholly encloses the motor adjacent the base of the casing and permits adjustment of the projector around the motor as an axis.

1,816,360. **Electrical Sound Reproducing Process Employing Metal Sound Record.** A. J. CAWLEY. Assigned to Radio Corporation of America. July 28, 1931. An all-metal electrically conducting photographic sound record is provided and the reproduction of sound controlled by the variation of the conduc-

tivity of a control circuit of a sound reproducing amplifier system. The metal sound record may be directly impressed upon a silver coated copper strip or a celluloid film may be softened by suitable solvents and metallic powder sprinkled over its surface. Heat and pressure are then applied, so that the particles are incorporated in the film; a metallic film is then electrically deposited upon this. The latter will adhere to the particles, and thus be held firmly to the film. The sound record of variable resistance is passed between a pair of brushes which lead to the input circuit of a sound reproducing amplifier for controlling the reproduction of sound therefrom.

1,816,397. **Sound Recording and Reproducing Monitoring Apparatus.** F. H. OWENS. Assigned to Owens Development Corp. July 28, 1931. Provision is made for listening in on the sound record at the time sound is being recorded or at the time of sound reproduction so that the operator can judge as to the volume and quality of the sound. Two recording lamps are provided and connected in series. One recording lamp operates directly upon the film while the other recording lamp operates upon a light-sensitive cell in an auxiliary pick-up circuit. The second recording lamp serves as ballast or resistance for the first recording lamp and prevents overloading thereof.

1,816,409. **Non-inflammable Protecting Coating to Motion Picture Films.** L. L. STEELE. Assigned one-half to T. Moore of Washington, District of Columbia. July 28, 1931. A motion picture film is provided with a coating on each side which will not take flame if the film for any reason stops before the arc of the projecting machine; that will not take flame from contact with a lighted cigarette; that will maintain its original pliability under the destructive action of the intense rays of the arc light for a markedly longer time than the original film (thereby increasing the useful life of the film), and very materially curtailing fire hazard; that will be practically scratch proof in so far as injury to the gelatin emulsion image is concerned and which will decrease the tendency for dust, oil, or other foreign matter to adhere to the film, make it possible to clean films without injury to them in the process, and make films absolutely waterproof. The coating which is applied to the film has optical properties such that the projection values of the coated film are enhanced, that is, a brighter, clearer picture results on the screen.

1,816,831. **Combined Electrical Recorder and Reproducer for Phonographs.** O. M. DUNNING. Assigned to Thomas A. Edison, Inc. August 4, 1931. A stylus arm is provided with two stylus points, that is, a recording stylus and a reproducing stylus. The stylus arm is mounted in such a manner that the recording stylus may be vibrated from an electrical system for placing a sound groove on the sound record or the reproducing stylus may be moved into position for vibrating an armature within an electromagnetic field and generating current which may be used to operate an amplifier system and control a sound reproducer.

1,816,832. **Simultaneous Control of Two Reproducers by Film Switches.** C. W. EBELING. Assigned to Harrison W. Rogers, Inc. August 4, 1931. Two film-controlled switches are provided for controlling two sound reproducing machines for operation one at a time. The sound reproducing machines are selectively started and stopped by the film-controlled switches in accordance with the movement of the film. A sound amplifier and reproducer is connected

with the sound reproducing machine which is in operation according to the switch which is controlled by movement of the film.

1,816,989. **Light-Sensitive Layer.** M. P. SCHMIDT. Assigned to Kalle & Co. Aktiengesellshaft. August 4, 1931. A light-sensitive layer containing diazo compounds of aromatic amino-acylamines. For the preparation of light-sensitive layers and diazo copies thereof, diazo compounds are particularly well suited which contain in the aromatic nucleus besides the diazo group also an acyl-amino-group; it is of no consequence whether the diazo compound is applied together with the azo component and then developed with an alkaline bath, or whether the diazo compound is applied alone and developed after the exposure to light with an alkaline solution which simultaneously contains an azo component. The said diazo compounds have not only a very good stability and sensitiveness to light, but they yield dyestuff-pictures which are especially fast to light. The acyl residue may, for instance, be an acetyl group, a benzoyl group, or a naphthoyl group. Two amino groups can also be connected by carbonic acid residues or by thiocarbonic acid residues, or by residues of other polyvalent acids, *e. g.*, succinic acid; for instance, diazo compounds and tetrazo compounds of aromatic urea or thiourea are suitable. The aromatic residue having the diazonium group attached may be substituted. Preferably hydroxy-alkyl-groups have proved to be suitable substituents.

1,817,026. **Motion Picture Projector Employing Three Shafts of Light.** W. L. WRIGHT AND S. M. WRIGHT. August 4, 1931. A film is provided having a series of pictures each including three pictures arranged longitudinally on the film. A source of light is divided into three separate shafts of light in close proximity to each other and directed through the pictures in a series, three lens devices receiving the shafts of light after passing the film and directing the shafts of light onto a screen. One of the lens devices is offset with relation to the others. A prism is arranged to offset one of the shafts of light so that it passes through the offset lens device. The several pictures are projected in such manner that different light filtering means may be applied to the different shafts of light for producing predetermined effects during the projection of the pictures.

1,817,177. **Binaural Reproduction from Disk.** F. M. DOOLITTLE. Assigned to Radio Corporation of America. August 4, 1931. The effect of actual position or movement of the sound is obtained in sound reproduction by providing a sound record with two concentric sound tracks in which different stylus needles operate for controlling separate sound reproducing circuits simultaneously. The original records of the sound and the different tracks are made in accordance with the arrival of the sound from the original sound series to a pair of fixed predetermined points so arranged as to simulate the binaural effect which would be produced upon the ears of a listener similarly positioned. In the reproduction of the sound through separate stylus devices, the same binaural effect is reproduced.

1,817,217. **Film Spool and Mounting.** A. F. VICTOR. August 4, 1931. The side plates of the reel for carrying film are provided with central apertures of different shapes through which a spindle extends and provides locking engagement with the sides of the film reel. A rigid driving connection is assured by virtue of the arrangement of apertures of different shapes in the sides of the reel coöperating with portions of the driving spindle of corresponding polygonal formation.

1,817,320. **Motion Picture Printing Apparatus.** F. H. OWENS. Assigned to Owens Development Corp. August 4, 1931. Two negative films having separate records thereon may be utilized to print a single positive film for synchronous reproduction. The printer is particularly adapted for reconstructing a silent motion picture into a talking picture by combining parts of the film negatives already available. A construction of drum is provided over which one negative and the positive film are driven and subjected to light which passes through the interior of the drum and in alignment with a second negative film, the records from which are impressed upon the positive film.

1,817,502. **Scanning Disk for Television.** V. K. ZWORYKIN. Assigned to Westinghouse Electric & Manufacturing Co. August 4, 1931. Scanning disk wherein a transparent rotatable plate is provided with a plurality of opaque spots spirally positioned thereon. The arrangement of parts of the scanning disk is reversed over that normally employed as in the present instance the main portion of the scanning disk is transparent while the spirally disposed spots are opaque. A larger amount of light is obtained from the glow discharge tube by this arrangement as the major portion of the glow lamp electrode is always completely visible through the viewing aperture during the scanning operation.

1,817,612. **Reproducing System Employing Modulated High Frequency Currents.** P. H. CRAIG. Assigned to Invex Corp. August 4, 1931. Sound reproducing system in which a super-audible oscillator is connected to impress control current upon a loud speaker and the oscillator modulated in accordance with sound vibrations from a phonograph record for the reproduction of sound. A circuit is coupled between the super-audible oscillator and the loud speaker which serves to modulate the high frequency energy in its passage to the loud speaker circuit. A rectifier is provided in the loud speaker circuit so that the high frequency energy is first modulated and rectified for the reproduction of sound.

1,817,630. **Vibrating Motion Picture Screen for Sound Reproduction.** J. C. KROESEN. August 4, 1931. A motion picture screen having magnetic material incorporated directly in the screen so that the screen itself may be vibrated by electromagnetic forces applied directly to the magnetic material incorporated in the screen. The screen is used for both the display of pictures and the propagation of sound waves by vibration thereof under control of the electromagnetic means positioned at different points throughout the area of the rear of the screen.

1,817,661. **Safety Device for Motion Picture Projecting Machines.** J. F. ADAMS, *et al.* Assigned to Sentry Safety Control Corp. August 4, 1931. Switch for protecting motion picture projecting machines by cutting off the rays of light from the film under conditions of stoppage of the film for preventing accident and fire hazard. A douser is provided, adapted to be shifted into the path of light rays. A mechanism including a notched disk engaged by a trigger is provided for holding the douser out of the light obstructing position. An electromagnet is arranged to actuate an armature carried by the douser holding means to release the same upon actuation. A set of contacts is associated with the douser which operates when the douser drops for cutting off the motor circuit.

1,817,728. **Film Numbering Machine.** P. C. ARMITAGE. Assigned one-half to P. W. Newcomer of Pomona, Calif. August 4, 1931. A numbering machine for applying an identifying number on an envelope containing one or more films, which number appears on the film after being developed and printed so that

the danger of getting films of several customers mixed is eliminated. The device comprises a casing upon which the film enclosed in an envelope may be supported and exposed to light rays which pass through a window and through the numbering portion of the flap of the envelope for photographing the number upon a portion of the film which is pressed against the flap. The casing contains both a white and ruby lamp which may be alternately used. The ruby lamp will give enough illumination to permit the envelope and film to be properly positioned over the window in the casing preparatory to a printing operation using the white lamp.

1,817,781. **Photoelectric Cell and Sound Reproducing Drum.** OSCAR STEINER. Assigned to General Electric Co. August 4, 1931. The sound film is guided over a rotatable drum located between the film supply and storage reels. The rotatable drum has a circumferential opening therein which is bridged by the film. The parts on the opposite side on the circumferential opening are secured together in fixed relation on opposite sides of the opening. A photoelectric cell which receives the light passing through the opening is located between the separate parts of the drum so that light of an external source may be passed through a slit adjacent the drum and through the circumferential opening in the drum for passage through the film.

1,817,963. **System of Color Photography.** J. G. CAPSTAFF. Assigned to Eastman Kodak Co. August 11, 1931. A film for taking natural color pictures which consists of a single light transmitting support with a panchromatic emulsion on one surface of the support. The other surface carries minute lenticular elements particularly adapting the film for a color process of a type requiring light rays to pass through the support before reaching the emulsion, there being in the film sheet a layer including a dye absorptive of light of all colors and positioned between the emulsion layer and the opposite surface of the film sheet and transmitting at least seventy per cent of light passing once directly through said layer and unaffected by ordinary photographic baths.

1,817,977. **Iris or Fade-In Effect in Motion Picture Film.** P. FAVOUR. Assigned to Eastman Kodak Co. August 11, 1931. A separate film strip is applied to a motion picture film for obtaining a fading effect at desired points along motion picture film. The applied strip extends over a predetermined length of the film and is provided with apertures adjacent each of the frames of the motion picture film, which apertures vary in size for producing an "iris" effect by which a gradual transition such as a "fade-in" effect is obtained in the projection of the motion picture. The applied strip has a greater light retarding effect adjacent one end than at the other end and the ability to transmit light varies from area to area in accordance with the size of the apertures in the applied strip.

1,818,354. **Composite Photographic Method and Apparatus.** R. J. POMEROY. Assigned one-half to Paramount Publix Corp. August 11, 1931. Two independent cameras are focused upon the subject which is illuminated before a nonactinic ground. The two films are simultaneously exposed by light splitting. One film has an additional amount of light thrown thereon so that it is relatively overexposed. When this overexposed film is developed, a substantially opaque mask image of the subject is formed. The other film is masked with the mask image and by exposure to the desired background; the subject image of the second film is combined with an image of the background. The cameras may be

adjusted both laterally and vertically so that a similar image is produced on each film. However, an auxiliary light is focused upon the film in one camera so that overexposure results, allowing the combining process to be effected during the development period.

1,818,355. **Adjustable Lens Holder.** W. C. READEKER. August 11, 1931. An adjustable lens holder which may be moved to different projection positions such that images may be projected in a plurality of directions at relatively different angles. A prism is mounted upon a frame member in such manner that the prism may be rotatably adjusted to control the deflection of light rays in different directions. The device is designed particularly for portable motion picture machines for facilitating the projection of pictures upon a desired surface.

1,818,432. **Intermittent Feed Mechanism.** G. ROUILLER AND J. MARION. August 11, 1931. Structure of intermittent film feed mechanism designed to obtain the least possible obturation owing to variable angular movement of the shutter with parts of the projector to which the mechanism is applied arranged for ventilation between the parts. The obturator has equidistant vanes and is mounted on a central axis of rotation. There are fan blades on these vanes for setting up ventilating currents to pass through the lantern casing. There is a pin on the obturator eccentric with the axis thereof, which pin engages a link for predetermining the position of the obturator and insuring coöperaton between the film feeding means and the obturator during framing.

1,818,499. **Filter Mounting Frame.** A. B. MUELLER. Assigned to Postergraph, Inc. August 11, 1931. A frame for mounting a filter where the filter may be quickly shifted or removed for permitting a change of plates and a quick resetting thereof at exactly the same distance from the light source. The frame has a pair of independent reels slidably mounted for supporting the frame members, the frame members being adjustable on the reels and being held in parallel relation thereto. A gear actuator is provided for effecting quick adjustment of successive screens or filters in the frame.

1,818,502. **Sound Reproducing Apparatus.** FREEMAN H. OWENS. Assigned to Owens Development Corp. August 11, 1931. A guide for sound film in which a rotatable sprocket and an idler roller are mounted for rotation upon an aligned axis for moving the film adjacent a light station or point of translation. A photoelectric cell is disposed between the idler roller and the drive sprocket closely adjacent the film and subjected to variations in light in accordance with the record on the film.

1,818,718. **Synchronous Control of Color Screens.** H. A. KLIEGL. Assigned to Kliegl Bros. Universal Electric Stage Lighting Co., Inc. August 11, 1931. The color screens are mounted in a rack in which each color screen is angularly shiftable under magnetic control in the path of the spotlight. The movement of each color screen is controlled by a small Selsyn motor. Each Selsyn motor is connected by line wire to a Selsyn generator at the control position. The operator, by rotating a knob on the Selsyn generator at the control position, sends control current over the line for operating the motor at the spotlight control for moving the desired screen into the light beam. By twisting the different generator shafts to the control position, the desired color screens may be moved into position in front of the spotlight.

1,818,760. **System Employing a Braun tube for Drawing Electrical Pictures.** P. SELENYI. Assigned to Egyesult Izzolampa Es Villamossagi Reszvenytarsasag, of Ujpest, Hungary. August 11, 1931. A sharply defined bundle of cathode rays generated in a Braun tube is set in motion by circuits terminating adjacent the tube for describing a variable path over a recording screen at the end of the tube. The path of the moving rays on the screen leaves a permanent but invisible mark on it, in the shape of a line drawn with electrical charges. The negative charges constantly conveyed by the cathode rays mark the path of travel of the pencil of rays on the spots of the screen hit by them, by getting fixed on the highly insulating material of the screen, and forming thereon an invisible line, drawing, or picture—according to the character of motion and intensity of the rays—consisting of negative charges imparted to the spots of the screen hit by the pencil of rays. This invisible "electrical picture" is made visible in a manner similar to that used in producing the well-known "Lichtenberg-figures," *i. e.*, by spraying the screen with a fine electrically charged powder. A mixture of fine, powdered sulfur and minium is employed for this purpose. When this mixture is sprayed on the screen by a current of air produced, for instance, with a rubber-ball sprayer, the sulfur acquires a negative, the minium a positive charge, and therefore the minium particles adhere to the negatively laden spots of the screen, thereby making the "electrical drawing" visible in red lines.

1,818,862. **Double Amplifying System.** R. A. MILLER. Assigned to Bell Telephone Laboratories, Inc. August 4, 1931. A sound recording system where two separate transmitters are provided in connection with two amplifiers to a recording camera. The leads between the transmitters and the recording camera may be of substantial length. There is a light-valve string controlled by the main amplifier with a switch provided for quickly short-circuiting the light-valve string and de-energizing the amplifier. Either one of the sound pick-up channels may be used independently and in conjunction with volume control circuits for effecting the recording of sound under different conditions.

1,818,927. **System of Color Photography.** J. N. GOLDSMITH. Assigned to Spicers, Limited, of London. August 11, 1931. A motion picture film is coated with a constituent of coloring matter upon which there are impressed geometrical patterns on the surface of the film. There is then successively impressed upon the film one or more media, each containing a compound capable of reacting with the constituent to form a differently colored coloring matter. The coating originally applied to the film comprises a solution of the anilide 2:3 oxynaphthoic acid in alcoholic potash. The pattern formed on the film may comprise red lines developed by ruling on lines of a solution of diazotized 2:5 dichloraniline. Blue lines may be developed on the film by ruling on lines of a solution of 4 amino 4′ ethoxy diphenylamine.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

BOOK REVIEW

Television. Edgar H. Felix. *McGraw-Hill Book Co.*, New York, N. Y., 1931, 271 pp.

Covers the progress of television up to the early part of 1931. In contrast to most articles and books on television, the author refrains from making great promises on the future of television. The book is devoted entirely to a review of old and new developments in the art.

The development of television has been mostly along lines of perfecting old ideas rather than along the lines of radically new inventions. While some parts of the television equipment are satisfactory in their present form, other parts are quite inadequate. One of the most desired discoveries is one which will conserve the use of radio channels. Of the two basic means of communication, aural and visual, the visual is by far the most complex, due to color (frequency), intensity, and direction.

There are six major steps in the process of television: (1) scanning; (2) conversion of light impulses into electrical impulses; (3) transmission; (4) reception; (5) conversion of electrical impulses into light impulses; and (6) the arrangement of these light impulses into a recognizable picture.

Scanning may be of the progressive observation or the progressive illumination type. That is, the field of view may be either fully illuminated, with the photoelectric cell placed in back of the scanning disk, or the photoelectric cell may be so placed that it commands the full field of view, and the illuminating obtained by placing the source of light behind the scanning disk. The light-sensitive element used must be capable of responding instantaneously to changes of light, and must have a linear response over the full color range. Selenium cells are not satisfactory, due to their time lag. Caesium cells are the most satisfactory for this service although they do not have the same characteristic as the eye.

In transmission, most of the troubles are due to the wide frequency band needed. In order to give a hundred line picture at twenty repetitions a second, a hundred kilocycle band is required. In reception, a special receiver is required. The author believes that the most likely receiver to be used will be one having three channels with suitable filters for separating the picture, the sound, and the synchronizing waves.

For converting the received signal into light impulses several methods have been devised. The neon glow tube is the most popular. However, some developmental work has been carried on using a special cathode ray tube as well as a large neon grid screen. The latter method has the disadvantage of requiring a special selector switch.

In forming the light impulses into a recognizable picture, the scanning process described above must be reversed. However, this system does not hold much promise for home use, as to give a picture with the same amount of detail as seen in motion pictures would require a disk twelve feet in diameter, which would have a peripheral speed of ten miles a minute.

One of the big problems now confronting experimenters is synchronization. Manual control requires constant attention and continual adjustment. Power line synchronization, although satisfactory, limits the distance of transmission to the territory served by the power company.

The author rounds out his discussion of television with a review of the possibilities for commercial television and describes the type of programs most suitable.

A. H. HAAK

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H. C. SILENT, *Manager*
L. E. CLARK, *Treasurer*

CONTRIBUTORS TO THIS ISSUE

Bielicke, W. P.: Born September 12, 1905, at Munich, Bavaria. Technische Hochschule, Berlin, Germany, 1927–29; Consolidated Film Industries, Hollywood, Calif.; in charge of laboratory work, RCA Photophone, Inc., 1929 to date.

Chambers, G. A.: See October, 1931, issue of JOURNAL.

Dimmick, G. L.: Born December 7, 1905, at Macon, Miss. Missouri University, 1928; talking motion picture development engineer, General Electric Company, 1928–30; RCA Victor Company, 1930 to date.

Dreier, Hans: Born 1885 at Bremen, Germany. Bremen Gymnasium, Munich University. Supervising architect, Imperial Government, Cameroons, West Africa, 1912–14; art director, Paramount Publix Corporation, Berlin, Germany; art director, Paramount Publix Corporation, U. S. A., 1923 to date.

Dunning, C. H.: Inventor deckle edging machine, 1904; president, Pencil Supply Company, inventor pencil printing machinery, 1907–17; vice-president, Prizma, Inc., 1918–23; inventor color photographic methods and president, Dunning Process Company, 1926 to date.

Foster, D.: Born March 19, 1900, at West Torbrook, Nova Scotia. Ph.D., Yale, 1924; engineer, Eastman Kodak Company, 1924–25; physicist, Bell Telephone Laboratories, 1925 to date.

Grignon, L. D.: Born March 24, 1904, at Washburn, Wis. B.S. in electrical engineering, University of California, 1925; transmission engineer, Pacific Telephone and Telegraph Company, 1925–27; supervisor of public address, Pacific Telephone and Telegraph Company, 1927–29; operations engineering, sound department, West Coast Studio, Paramount Publix Corporation, 1929 to date.

Harcus, W. C.: Born 1896 at Pawtucket, R. I. Master Signal Electrician, American Expeditionary Forces, 1918–19; B.S. in mechanical engineering, Worcester Polytechnic Institute, 1921; plant transmission engineering department, Pacific Telephone and Telegraph Company, 1921–26; supervising engineer, general engineering department, Pacific Telephone and Telegraph Company, 1926–29; chief engineer, sound recording plant, West Coast Studio, Paramount Publix Corporation, 1929 to date.

Huse, E.: See October, 1931, issue of JOURNAL.

Jones, L. A.: See May, 1931, issue of JOURNAL.

Mitchell, G. S.: Electrical engineering, California Institute of Technology; Department of Water and Power, Los Angeles; sound department, Universal Pictures Corp.

SOCIETY ANNOUNCEMENTS

The Fall Meeting of the Society was held at Swampscott, Mass., October 5th to 8th, with headquarters at the New Ocean House. The technical program consisted of forty papers, in addition to reports by the various committees of the Society. The papers program was substantially the same as that published in the October issue of the JOURNAL, with a few minor changes in order of presentation.

The exhibit of motion picture apparatus held in the Colonial Room of the New Ocean House included apparatus representing twenty-one manufacturers, as well as a number of replicas of sound and picture projectors made by E. A. Lauste as early as 1912.

On Wednesday, October 7th, inspection trips were made by the visitors attending the Convention to the Massachusetts Institute of Technology, the Harvard University, the plant of the General Electric Company at Lynn, and various points of historical interest along the Massachusetts coast.

On the evening of Sunday, October 4th, and on three succeeding evenings those attending the Convention were entertained by exhibitions of recent films of interest. The Society is indebted to the following firms for their courtesy in arranging the loan of these films: Columbia Pictures Corporation, Educational Film Exchanges, Inc., Electrical Research Products, Inc., Fox Films Corporation, General Electric Company, Metro-Goldwyn-Mayer Pictures Corporation, Paramount Publix Corporation, RKO-Pathé Pictures, Inc., RKO Radio Pictures, Inc., United Artists Corporation, University Film Foundation, Warner Brothers Pictures, Inc.

Mr. Norman McClintock of the Koppers Research Corporation, Ligonier, Pa., lectured on Monday evening, October 5th, on "Wonders of the Commonplace." The lecture was illustrated by four reels of motion pictures depicting time-lapse studies of the growth of plants and interesting features of bird and insect life.

As a part of the program Tuesday evening, October 6th, the visitors were shown the first complete photoplay made in the United States It is called *The Great Train Robbery* and was made by Mr. Edwin S. Porter, who wrote the scenario and served as cameraman and di-

rector. The interior scenes were made in New York and the exteriors in New Jersey in the fall of 1903. Mr. Porter also served as the projectionist at the first showing in 1904 in Coster and Bial's Music Hall on Broadway. Mr. Porter was present during the showing of the picture at Swampscott.

An example of the progress made in re-recording was shown by a sequence of the Fox picture *East Lynne*. Spanish words were synchronized very effectively with the lip movements of Clive Brook and Ann Harding. Both English and Spanish versions were projected.

A feature film, *Fanny Foley Herself*, made in Technicolor was shown on Tuesday evening and represented the first showing of a complete sound and color picture at a meeting of the Society. A marked improvement in the quality of the reproduced color and the definition, particularly on long shots, was observed in comparison with previous Technicolor productions.

One of the most interesting papers and demonstrations given at the technical sessions was that on "Vertical Sound Records," by H. A. Frederick of the Bell Telephone Laboratories. The equipment consisted of a disk reproducer for "hill and dale" records made on cellulose acetate, and a duplex loud speaker consisting of a small cone for the high frequencies and a larger cone for the lower frequencies. A consensus of opinion of those in attendance was that the reproduced sound was the finest that has ever been demonstrated at a convention of the Society.

Another paper which excited much comment was that on "The Problem of Projecting Motion Pictures in Relief," by Dr. H. E. Ives of the Bell Telephone Laboratories. Although Dr. Ives held no hope for a solution of this problem in the immediate future, he expressed the belief that the obstacles were not insurmountable and the progress made to date has been encouraging.

Suggestions for research problems were made by several committees, notably the Projection Practice, Projection Screens, and Sound Committees. The Projection Screens Committee reported results of preliminary measurements on screen brightness preparatory to making a recommendation on a standard.

Prizes for the most effective presentation of their papers were given by President Crabtree to the following: G. E. Matthews, R. P. Schwartz, H. E Ives, D. R. White, and H. A. Frederick.

The semi-annual banquet of the Society was held on Wednesday evening, October 7th, in the main dining room of the New Ocean

House, at which about two hundred and fifty persons were present. At the conclusion of his opening address, President Crabtree presented certificates to the following honorary members of the Society as formal recognition by the Society of the granting of these memberships:

Name	*Date of Election*
C. Francis Jenkins	October 4, 1926
George Eastman	April 13, 1928
Thomas Alva Edison	April 13, 1928
Frederic Eugene Ives	April 13, 1928
Louis Lumière	September 24, 1928
Eugene Augustin Lauste	October 4, 1931
Jean Acme LeRoy	October 4, 1931

Mr. Frederic E. Ives and Mr. Eugene Augustin Lauste accepted their certificates of honorary membership in person. Mr. C. Francis Jenkins, founder of the Society and its first honorary member, was unfortunately prevented by ill health from attending the convention; in his absence Mr. O. B. Depue accepted his certificate. In the absence of Mr. Edison, his certificate was accepted by Mr. A. Y. Attwell. President Crabtree represented Mr. George Eastman, and Mr. J. C. Joseph Flamand, French Consul at Boston, accepted the certificate for Mr. Louis Lumière. Mr. Merritt Crawford received the certificate on behalf of Mr. Jean Acme LeRoy.

Mr. Crabtree announced that the names of Louis Aime Augustin Le Prince and William Friese-Greene had been placed on the honor roll of the Society. Miss G. Marie Le Prince, daughter of Mr. Le Prince, replied for her deceased father.

The presentation of each certificate was preceded by short historical reviews of the work done by the various pioneers. These reviews were made by President Crabtree, Mr. Merritt Crawford, Mr. Carl L. Gregory, Mr. Terry Ramsaye, and Mr. Glenn E. Matthews. Mr. Oscar B. Depue and Mr. A. S. Victor were also present at the speaker's table.

President Crabtree announced the offer by Mr. George Eastman to the Society of fifteen hundred dollars to be used in the establishment of a fellowship in one of the eastern universities, the recipient of which is to devote his time to the study of problems relating to motion picture engineering.

A great deal of credit must be given to the Convention Committee under the chairmanship of Mr. W. C. Kunzmann, and the local Arrangements Committee headed by Mr. J. S. Cifre for the large

amount of work which they contributed toward making the Convention a success. Thanks also are due to Mrs. A. C. Hardy and her committee for arranging an attractive program for the ladies attending the Convention. The Society is also indebted to Mr. H. Griffin, chairman in charge of projection equipment, installation, and operation; to the RCA Photophone, Inc., for the installation of sound equipment, and to Mr. J. S. Frank, Jr., and Dr. Olsen for its supervision; to officers and members of Projectionists Local 245 I.A.T.S.E., Lynn, Mass.; to Mr. O. M. Glunt, and the entire Papers Committee, of which he is chairman, for the interesting papers program which was arranged.

ELECTION OF OFFICERS

The ballots for the election of new officers for the year 1931–1932 were counted by an appointed committee of tellers at the Monday morning meeting, October 5th, and the following results were announced by President Crabtree:

President	A. N. GOLDSMITH
Vice-President	E. I. SPONABLE
Secretary	J. H. KURLANDER
Treasurer	H. T. COWLING
Governor	L. C. PORTER
Governor	O. M. GLUNT

BOARD OF GOVERNORS

At a meeting of the Board of Governors held in the New Ocean House at Swampscott, Mass., on October 4th, the annual audit of the Society's finances was submitted by Mr. H. T. Cowling, treasurer. This audit was included in the report of the treasurer presented at the meeting of the Society on October 5th.

Honorary memberships were awarded to Eugene Augustin Lauste and Jean Acme LeRoy, and authority was given to prepare an appropriate certificate for presentation to all honorary members of the Society. These certificates were presented at the semi-annual banquet on October 7th.

In addition, the Board voted to establish an Honor Roll upon which are to be placed the names of distinguished pioneers in motion picture engineering who are deceased. The names Louis Aimé Augustin Le Prince and William Friese-Greene were placed upon this Honor Roll in the order given. Names of deceased honorary members are also to be added to this Roll.

REVISION OF BY-LAWS

The following amendments to the Constitution and By-Laws were approved by the Board of Governors on October 4th.

BY-LAW I

Membership

Section 1 (*a*). A motion picture engineer by profession. He shall have been *engaged* in the practice of his profession for a period of at least three years and shall have taken responsibility for the design, installation, or operation of systems or apparatus pertaining to the motion picture industry.

BY-LAW VI

Elections

An addition was made to Section 1 of this By-Law, as follows:
The newly elected officers of the General Society shall take office at the adjournment of the annual fall meeting.

BY-LAW VII

Dues and Indebtedness

Section 1. *The entrance fee for applicants for admission to the grade of Active membership shall be $30.00.*
Section 2. *The transfer fees from Associate to Active grade shall be $30.00.*
Section 5. Members shall be considered delinquent whose dues remain unpaid for four months. Members who are in arrears of dues for 30 days after notice of such delinquency, mailed to their last address of record, shall have their names posted at the Society's headquarters which shall be the *General Office* and notices of such action mailed them. Two months after becoming delinquent, members shall be dropped from the rolls if non-payment is continued.

BY-LAW IX

Publications

Section 1. *Papers read at meetings or submitted at other times, and all material of general interest shall be submitted to the Editorial Board, and those deemed worthy of permanent record shall be printed in the Journal. A copy of each issue shall be mailed each member in good standing to his last address of record. Extra copies of the Journal shall be printed for general distribution and may be obtained from the General Office on payment of a fee fixed by the Board of Governors.*

BY-LAW X

Local Sections

Membership

Section 2. *All members of the Society of Motion Picture Engineers in good standing residing in that portion of any country set apart by the Board of Governors tributary to any local section, shall be eligible for membership in that section, and when so enrolled they shall be entitled to all privileges that such local section may, under the General Society's Constitution and By-Laws, provide.*

Any member of the Society in good standing shall be eligible for non-resident

affiliated membership of any section under conditions and obligations prescribed for the section. An affiliated member shall receive all notices and publications of the section but he shall not be entitled to vote at sectional meetings.

Section 9, headed "Membership," is renumbered *Section 3*, and heading eliminated.

Section 3, headed "Officers," is renumbered *Section 4*.

Section 4, headed "Election of Officers," is renumbered *Section 5*, and changed to read as follows:

The officers of a section shall be active members of the General Society. They shall be nominated and elected under the method prescribed under By-Law VI, Section 1, for the nomination and election of officers of the General Society. The word "manager" shall be substituted for the word "governor."

All Section officers shall hold office for one year, or until their successors are chosen, except the board of managers, as hereinafter provided.

Section 5, headed "Managers," is renumbered *Section 6*.

Section 6, headed "Business," is renumbered *Section 7*.

Section 7, headed "Expenses," is renumbered *Section 8*, and the following changes made:

(*c*) The Secretary-Treasurer of each section shall send to the treasurer of the General Society, *quarterly or on demand*, an itemized account of all expenditures *incurred during the preceding interval.*

(*d*) *Expenses other* than those enumerated in the budget, as approved by the Board of Governors of the General Society, *shall not be* payable from the general funds of the Society *without express permission from* the Board of Governors.

(*e*) A section Board of Managers *shall defray all expenses not sanctioned by the Board of Governors from funds raised locally, by assessment, or by fixed annual subscription, or by both.*

Section 2, headed "Meetings," was renumbered *Section 9* and changed as follows:

The regular meetings of a section shall be held in such places and at such hours as the *Board of Managers may designate.*

The Secretary-Treasurer of each section shall forward to the Secretary of the General Society, not later than five days after a meeting of a section, a statement of the attendance and of the business transacted.

Section 8, headed "Papers," was renumbered *Section 10*.

All the above amendments were approved at the open meeting of the Society on October 6th with the exception of By-Law VII, Sections 1 and 2, relative to abolishing the entrance fees for associate membership, at which time it was resolved to refer this amendment back to the Board of Governors for further consideration. In addition, at the same meeting, it was voted to change the word "assessment" in Section 7(*e*) of By-Law X to "donation."

S. M. P. E. FELLOWSHIP

Mr. Crabtree announced the offer by Mr. George Eastman of fifteen hundred dollars to be used for establishing a fellowship, the

recipient of which is to devote his time to the study of problems relating to motion picture engineering. The Board of Governors voted to accept this kind offer, and moved that the administration of the funds be left to the succeeding Board of Governors.

NEW YORK SECTION

At a meeting held in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., on October 29, 1931, Mr. E. W. Kellogg of the RCA Victor Company, Inc., Camden, N. J., presented a paper discussing the problems and results obtained in recording on 16-mm. film by the variable width method. A demonstration accompanied the paper.

The results of the election of officers of the New York Section were announced by the committee of tellers as follows:

Chairman, PORTER H. EVANS
Secretary-Treasurer, DONALD E. HYNDMAN
Manager, MAX C. BATSEL
Manager, JOHN L. SPENCE, JR.

Dr. A. N. Goldsmith, recently elected President of the Society of Motion Picture Engineers, and Mr. P. H. Evans, Chairman-Elect of the New York Sections, were introduced. Approximately one hundred and seventy-five persons attended the meeting.

COMMITTEE FOR PRESERVATION OF HISTORICAL FILMS

Mr. J. I. Crabtree has agreed to serve, together with Mr. L. B. Newell of the New York Fire Insurance Exchange, 85 John Street, New York, N. Y., on a committee appointed by Mr. Will H. Hays to make recommendations to President Hoover with regard to suitable methods of preserving historical motion picture films in the proposed Archives Building in Washington.

INTER-SOCIETY COLOR COUNCIL

The first meeting of the Inter-Society Color Council was held in the Museum of Science and Industry, New York, N. Y., on September 21st. Delegates from about sixteen societies interested in the standardization of color nomenclature and specifications were present. It is understood that the Color Council will act not as an independent society, but more as a congress for the purpose of assimilating and putting into concise form the widely diverse activities of the groups

engaged in color work in each society. Mr. L. A. Jones, a past-president of the Society of Motion Picture Engineers, was elected vice-chairman of the Council.

The Society of Motion Picture Engineers was represented by Mr. R. M. Evans. As this meeting was mainly for organization purposes, it is of present interest to note only that plans were made for forming committees on (1) membership in the Council, (2) color nomenclature, and (3) measurement and specification of color. The next meeting of the Council is scheduled to be held prior to January 1, 1932.

ACADEMY OF MOTION PICTURE ARTS AND SCIENCES

Mr. M. C. Levee, executive manager of Paramount Studios, was recently elected president of the Academy of Motion Picture Arts and Sciences, succeeding Mr. William C. de Mille, who has held the office for the past two years.

Other officers elected were: Mr. Conrad Nagel, re-elected vice-president; Mr. Fred Niblo, re-elected secretary; and Mr. Frank Lloyd, named as treasurer. Messrs. Clinton Wunder and Lester Cowan were re-elected executive vice-president and executive secretary, respectively.

Mr. Frank Capra, a director, and Mr. Max Ree, an art director, took their places in the board of directors as new members elected for three-year terms. Former directors re-elected for terms of the same length are Messrs. M. C. Levee, Benjamin Glazer, and Conrad Nagel.

The Society regrets to announce the death of one of its honorary members,

THOMAS ALVA EDISON

on October 18, 1931. By action of the Board of Governors, Mr. Edison's name is hereby added to the

HONOR ROLL

of the Society of Motion Picture Engineers. A detailed account of Mr. Edison's accomplishments will be given in a later issue of the JOURNAL.

The Society regrets to announce the death of Mr. H. Frank Johnson, on September 9, 1931, at Angola, Indiana.

HONOR ROLL

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

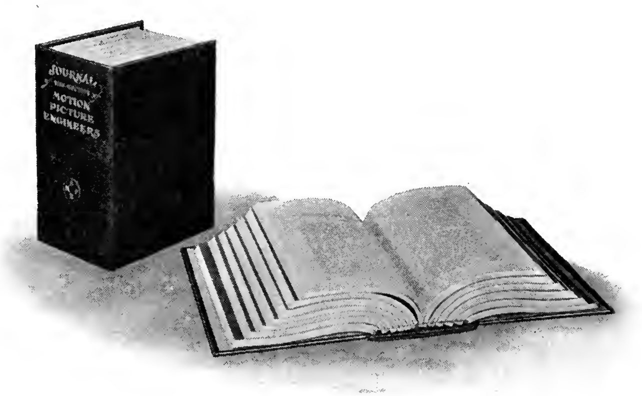
Louis Aimé Augustin Le Prince

William Friese-Greene

Thomas Alva Edison

JOURNAL BINDERS

The binder shown in the accompanying illustration serves as a temporary transfer binder or as a permanent cover for a complete



year's supply of JOURNALS. It is made of black crush fabrikoid, with lettering in gold. The binder is so constructed that each individual copy of the JOURNAL will lie flat as its pages are turned. The separate copies are held rigidly in place but may be removed or replaced at will in a few seconds.

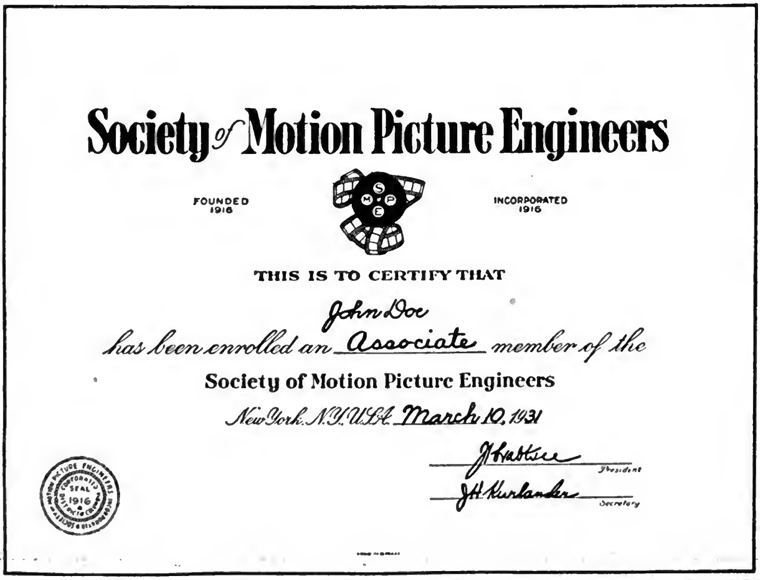
These binders may be obtained by sending your order to the General Office of the Society, 33 West 42nd Street, New York, N. Y., accompanied by a remittance of two dollars. Your name and the volume number of the JOURNAL may be lettered in gold on embossed bars provided for the purpose at a charge of fifty cents each.

LAPEL BUTTONS

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of one dollar.

MEMBERSHIP CERTIFICATE

Associate members of the Society may obtain the membership certificate illustrated below by forwarding a request for the same to the General Office of the Society at 33 W. 42nd St., New York, N. Y., accompanied by a remittance of one dollar.



Society of Motion Picture Engineers

FOUNDED 1916

INCORPORATED 1916

THIS IS TO CERTIFY THAT

John Doe

has been enrolled an Associate member of the

Society of Motion Picture Engineers

New York, N.Y. U.S.A. March 10, 1931

J. I. Crabtree
President

J. H. Kurlander
Secretary

SUSTAINING MEMBERS

Agfa Ansco Corporation
Bausch & Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Carrier Engineering Corp.
Case Research Laboratory
Du Pont Film Manufacturing Corp.
Eastman Kodak Co.
Electrical Research Products, Inc.
General Theaters Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Paramount Publix Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

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1917	3	$0.25
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	38	3.00

Beginning with the January, 1930, issue, the Journal of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and Journals should be placed through the General Office of the Society, 33 West 42nd Street, New York, N. Y., and should be accompanied by check or money-order.

Statement of the Ownership, Management, Circulation, *Etc.*, Required by the Act of Congress of August 24, 1912. of *Journal of the Society of Motion Picture Engineers,* published monthly at Easton, Pa., for October 1, 1931.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and County aforesaid, personally appeared Sylvan Harris, who, having been duly sworn according to law, deposes and says that he is the Editor-Manager of the Society of Motion Picture Engineers and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), *etc.*, of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Name of— *Post Office Address—*

Publisher, Society of Motion Picture Engineers, 33 W. 42nd St., New York, N. Y.
Editor. Sylvan Harris, 33 W. 42nd St., New York, N. Y.
Managing Editor, Sylvan Harris, 33 W. 42nd St., New York, N. Y.
Business Manager, Sylvan Harris, 33 W. 42nd St., New York, N. Y.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Society of Motion Picture Engineers, 33 W. 42nd St., New York, N. Y.
J. I. Crabtree, President, Kodak Park, Rochester, N. Y.
J. H. Kurlander, Secretary, 2 Clearfield Avenue, Bloomfield, N. Y.
H. T. Cowling, Treasurer, 343 State Street, Rochester, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is: (This information is required from daily publications only.)

SYLVAN HARRIS, Editor, Business Manager.

Sworn to and subscribed before me this 18th day of September, 1931.

(Seal) KENNETH L. JEFFERY.
Notary Public, Westchester County,
Certificate filed in New York County,
Clerk's No. 48, Reg. No. 2-J-37.

(My commission expires March 30, 1932)

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVII **DECEMBER, 1931** **Number 6**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

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Entered as second class matter January 15, 1930. at the Post Office at Easton, Pa., under the Act of March 3, 1879.

ADDRESS OF WELCOME

DELIVERED AT THE OPENING OF THE FALL MEETING AT SWAMPSCOTT, MASS., OCTOBER 5, 1931

K. T. COMPTON*

When I first knew of the meeting here, one thing struck me more than any other, and that was that I know of no other industry that combines so many kinds of science and engineering as does the motion picture industry. For that reason, it is particularly interesting to us who are interested in education, especially in science and engineering, because it means that your organization has more contacts with ours, and ours with yours, than any other society or industry.

I suppose your work fundamentally is based on applied optics, so that you have the physicist specializing in that field, perhaps, at the background of the whole work. But then there are innumerable others that you know as well as I do, and your roster of the Society would, of course, point all of these out. You have the electrical engineer who is interested in communication, and the mechanical engineer who has to assist in the design of your complicated machinery. You have the chemical engineer, the photochemist, interested in problems of the film. Physical optics comes in, because there are so many developments that involve things other than the geometrical optics, of the optical systems, in the operation of your film, color effects, and so forth. Then you have in the design of your theaters the architect, and the heating and ventilating engineer, and so on.

I could go on for quite a while, listing the various types of engineering, and when finished, I should have run through the entire list of mechanized branches of engineering. One thing is particularly interesting and that, as always, has to do with newer developments. With the introduction of sound and color into the motion picture, you have tapped some fields which have quite recently and very rapidly been developed.

* President, Massachusetts Institute of Technology, Cambridge, Mass.

As a result of these cogitations, I cannot help thinking about what might be done and what ought to be done by our educational institutions in making some kind of effective contribution to the development of this field. This is a thing which is sure to come. I am sure that there are a number of different feasible ways in which your Society and our scientific and engineering schools would be mutually helpful.

If I have any excuse for speaking to you, except to bear the greetings and welcome from local institutions, it is perhaps because nearly twenty years ago I became particularly interested in the development of some of the scientific aspects of things that have recently become of very important use to your Society. I believe I am right in saying that it was my doctor's thesis which gave the first reasonably good experimental proof of Einstein's famous equation for the photoelectric effect, work which several years later was carried on with fine precision by Dr. Milliken, and in his hands led to an accurate determination of that famous physical constant known as Planck's constant. At that time I was associated with O. W. Richardson, under whom I was working. Richardson, a year or two ago, was given the Nobel prize for his developments in the field of emission of electricity from hot bodies, that field which underlies the modern thermionic amplifier. And in some work of eighteen years ago, we discovered the relationship between photoelectric emission and thermionic emission to this extent: we discovered what was the property of the metal which jointly determined the properties of the metal for photoelectric emission and thermionic emission. So there we have those two things which are really at the base of the application of sound in modern movies—the two things that make it possible to translate sound into light, light into sound—the photoelectric eye and the thermionic amplifier.

I have just one other thought. I mention this with some diffidence because I may be entirely wrong and may be maligning a great industry. But I had the opportunity for the first time last summer to visit some of the studios in Hollywood. I must confess that the first impression, to an outsider who has a somewhat disciplined mind and who likes things to go systematically, was that the work was carried on with what might be called a maximum degree of disorganization. I don't know whether that is due to the artistic temperaments that have to be dealt with in those productions, or even whether it is true. It may be that experience in the studios has proved that the particular way in which they do the work is the way which leads to the best

results. If so, my remarks have no point at all. But I did have it intimated to me from several sides that with the introduction of sound technic into the movies, and particularly the bringing in of engineers to coördinate and synchronize the activities in connection with shooting a picture, there was being introduced a considerable advance in what might be called the systematic organization of the process of shooting a picture.

I know there are many more important things for you to do than to listen to words of welcome. I want to repeat again the very cordial welcome from the local institutions. I am glad to see on your program that for tomorrow afternoon you have provided time for inspection trips to Harvard, M. I. T., and other institutions which are very much interested in your work. It is a particularly convenient time for you to visit our institution, because it happens that tomorrow morning it is to be inspected by a group of business executives who are visiting various research laboratories under the auspices of the National Research Council. We will, so to speak, be dressed up for the occasion. In concluding, President Crabtree, I want to reiterate the hearty welcome of these institutions to your Society.

PRESIDENTIAL ADDRESS

DELIVERED AT THE OPENING OF THE FALL MEETING AT SWAMPSCOTT, MASS., OCTOBER 5, 1931

For this, the fifteenth anniversary of our Society, I think it is fitting that we have chosen a location far from the madding crowd where we shall have more opportunity for mutual acquaintance and individual thought than is possible in a large city.

The world was never in greater need of new ideas than it is today. I am hopeful that in days to come we can trace many of the industry's outstanding technical achievements to ideas which had their birth at our Swampscott Meeting.

Although the period of my administration as your chief executive is almost ended, I feel happy that I have been privileged to assist in developing the Society to its present stage of prestige and usefulness to the industry. During the past two years several important milestones have been passed in the course of the Society's growth including the publication of a monthly JOURNAL instead of quarterly *Transactions* and the acquisition of headquarters in charge of a paid editor-manager while a considerable number of sustaining memberships have been acquired to contribute toward the necessary funds for these innovations.

Two new sections have been founded in New York City and Chicago, which have materially aided in furthering the objects of the Society. As a result of our conventions which have been held in the key cities of Washington, New York, and Hollywood, our Society has become better known to the production interests, the scientific world, and the nation at large.

Our Society has also made available a large amount of knowledge resulting from the coöperative efforts of the various committee members. The subject of projection has been given increasing attention by the Projection Practice, Projection Theory, and Projection Screens Committees. As a result of the efforts of the Standards Committee, an authentic glossary of technical terms employed in the industry has been published and also a booklet of

Standards adopted by the Society. This committee has also offered a solution to the wide film problem by recommending the adoption of a 50-mm. standard. The Progress Committee has provided the industry with a comprehensive bi-annual report of technical advances in the industry gathered from world-wide sources, while the Historical Committee has conducted researches and contributed several papers to our JOURNAL dealing with the accomplishments of some of the industry's engineering pioneers and has assembled an exhibit of historical apparatus in the Los Angeles Museum.

Valuable reports have been contributed by the Color, Sound, and Studio Lighting Committees, while the quality of the papers assembled by the Papers Committee for our conventions has been of the highest order. Any success which our conventions have achieved has been due largely to the efforts of the Papers, Convention, Membership, and Publicity Committees.

But our main concern is with the future, and with ways and means of increasing the usefulness of our Society to the industry. Now that the routine work of the Society is no longer a burden to the Society's officers, in future they will be able to devote more time to the organization and coördination of the Society's various activities.

One of the most pressing needs of the future is the wider distribution of our JOURNAL especially among the younger technicians in studios, laboratories, and theaters, who are anxious for the knowledge which it contains but cannot subscribe to it on account of its relatively high cost. It is our vital obligation to devise ways and means of reducing the non-member subscription price of the JOURNAL from $12 to $6.

This is not an easy matter to accomplish because our annual expenses are exceeding our income by about $6000 but fortunately, we have a treasury surplus of about $24,000 which will take care of this overrun for some years to come. It has been suggested that the deficit be taken care of by means of advertisements in the JOURNAL but I think it highly desirable to dissociate our activities from any semblance of commercialism and to maintain our JOURNAL as a compact library of technical information worthy of preservation in its entirety. Undoubtedly, an intensive campaign for JOURNAL subscriptions and sustaining memberships would take care of this financial situation and I have appointed a special committee to investigate the problem.

Our Society must also take a more aggressive part in the technical

activities of Hollywood. Our spring convention was the means of bringing more forcibly to our attention the fact that Hollywood is not merely the center of studio production but is rapidly becoming the leader in laboratory processing. Hollywood now contains more than 1000 technicians who are enthusiastic and anxious to coöperate, and the fact that this personnel is centralized makes it possible to get coöperative results quickly with a minimum of lost motion. A spirit of friendly rivalry keeps everyone constantly on his toes but the extreme pressure of work permits experimenting only on problems of immediate practical importance, and there is no time whatever for fundamental research.

In Hollywood there also appears to be a tendency for the production interests to rely almost entirely upon the Academy of Motion Picture Arts and Sciences for advice and collaboration on technical matters. This is only natural because the Academy is sponsored and subsidized by the producers themselves and the production executives take a personal interest in and devote much of their time to its various activities. With the support and interest of the higher executives, they are therefore tolerant that their employees shall spend the time and money of their firms in the interests of the Academy.

It should also be realized that the producers in Hollywood have agreed to be non-competitive—their only competition is rivalry in blending together the story, technical effects, and artistry to produce the best motion pictures possible.

Let us compare for a moment the activities of the Academy and our Society, and the objects for which each is striving. To date our interests have been focused largely on the tools of the industry and the fundamental principles of science which lead to their development. The attention of the Technicians Branch of the Academy, on the other hand, has been devoted largely to problems relating to the application to production of the tools which the engineer has already devised although, rightly, it has concerned itself with the tools themselves when suitable ones were not available, thereby stimulating the manufacture of more suitable equipment.

Since most producers are now also in the business of processing and exhibiting motion pictures, they should be interested in all technical problems of the industry and in the coöperation which our Society is capable of giving.

Both our Society and the Academy are concerned with four principal lines of endeavor, namely, education, publication, standardiza-

tion, and coöperative research. Let us examine more closely the activities of each organization in these categories with a view to determining where closer coöperation is possible.

One of the first activities of the Academy on the introduction of sound was the establishment of a school of instruction in sound, which was a means of quickly educating the production personnel in Hollywood in the elements of this new adjunct to motion pictures. Courses of lectures have also been given at universities but only those persons located in the west have been able to avail themselves of these opportunities.

To date, organized education has not been attempted by our Society. However, symposiums on various topics have been given at our semi-annual conventions and the discussions at the meetings of the various sections in New York, Chicago, and Hollywood have served to educate those interested. At each of our conventions tutorial lectures have been given on specific subjects by outstanding experts in their field and this policy should be continued.

Also, as a result of encouragement by our Society and our offer to assist in supplying special lecturers on specific topics, one of the eastern universities is considering the establishment of a special course in the fundamentals of the various sciences which are particularly applicable to the motion picture industry. This work should be pushed forward with a view to soliciting the assistance of other educational institutions. It is the obligation of the industry to give its moral and financial support to such a project because it will be the means of supplying the industry with man power adequately grounded in fundamentals.

The officers of our sections should also make an effort to promote lectures on subjects appertaining to motion picture technology before various scientific groups and thereby bring greater prestige to our Society.

To date, the publication of technical knowledge by our Society has been restricted to articles in our JOURNAL. Publications by the Academy have consisted of pamphlets and books on specific subjects including incandescent lighting *vs.* arc lighting, the silencing of cameras, and sound recording. Much of the information in the latter publication was published in the *Transactions* of our Society two years previously although it was not quite as complete or in assembled form.

It is highly desirable that books and monographs on specific topics

be prepared and published under the sponsorship of our Society. Tentative plans for such publications are now under consideration.

However, there is need in the industry for all the educational facilities available. Even if the Academy and our Society do duplicate instructions, no harm will be done. On the other hand, the greatest benefit is often derived when two investigators tackle a problem independently—they often see the problem from different angles and their combined researches tend to constitute a more complete solution of the problem. Education of the masses is only effected by repeated doses.

One of the chief functions of an engineering organization is the standardization of mechanisms and practices. To date our Society has established standards for films and the essential parts of mechanisms which have been approved by the American Standards Association and have received international recognition. These have been published in booklet form and are available *gratis*. The Academy has performed a useful service in formulating a standard for release prints and is actively engaged in the study of various problems with a view to the standardization of practices.

Our Society has not been as aggressive as it ought to have been in effecting the standardization of practices. Such matters as the standardization of screen brightness, sizes of camera and projector apertures, the density characteristics of projection positives, the desirable gammas in the processing of film, the measurement of light intensity in the studio so that when a negative is developed to a definite constant gamma the print will give the artistic effect desired—these and other problems are urgently in need of solution.

These problems rightly come under the scope of activities of the Standards Committee which should charter the coöperation of the various committees for specific technical data and should encourage them to arrive at standard specifications. In most cases it will be necessary to perform research work or to secure experimental data. Although it is not the function of a technical society to establish a research laboratory, it can act as a collecting and coördinating medium for research and encourage various individuals and firms to contribute data and perform specific experiments.

It is unfortunate that in view of the competitive situation with regard to the tools of the industry many available technical data are deliberately being withheld from publication. However, when an outstanding technical society asks for specific information from these

firms the request is rarely refused so that by an aggressive attitude on the part of our Society, a great deal of valuable information could be assembled.

It is also quite possible for an aggressive committee to perform research work and tests, as instanced by the Projection Screens Committee which has conducted practical tests on screen brightness with the committee members as observers, and our Wide Film Subcommittee which has made practical tests with films of various sizes.

The difficulty involved is, of course, to find men who are willing to devote sufficient of their own time or are permitted to devote the necessary portion of their employer's time to the direction and following up of these problems. The only answer is that ultimately our Society must either make arrangements that its own manager shall continually stimulate these committees or that efforts be made to persuade some individual or an employee of some producing or manufacturing concern to devote his time exclusively to these problems.

Our Society can also assist in the more rapid accumulation of knowledge by creating the necessary funds for the establishment of fellowships in universities. Two universities have intimated their willingness, provided the necessary funds are forthcoming, to create such fellowships for investigations of a fundamental nature cognate to motion picture technology. The fellowships would be administered with the collaboration of our Society.

But what should be our policy toward Hollywood? We should establish headquarters there with a part or whole time paid secretary or manager. When these are established, it would be fitting to alternate the location of the national President and the majority of the Board of Governors between Hollywood and New York City. Duplicate committees should be appointed in both the East and West to study any given problem such as laboratory processing, studio lighting, projection practice, *etc.*, and the efforts of these committees should be carefully coördinated. It is also becoming increasingly necessary to hold a convention at least every two years in Hollywood.

Our Society can, of course, never be of the utmost service to the producer until their chief executives are tolerantly disposed toward the Society and realize more fully its potential value to them. Our recent convention in Hollywood was a most important factor in helping to establish this relation but there must be aggressive follow up work.

Although I have spoken previously of the excellent work of the

various committees, there is much useful work to be accomplished, and additional committees should be appointed. The responsibility for the technical merit of the contents of the JOURNAL should still rest in one individual, namely, the Chairman of the Papers Committee, and he should also be the Chairman of the Board of Editors whose main function is to review papers submitted by the Papers Committee. This Board, however, should consider carefully the expansion of the usefulness of the JOURNAL by establishing sections dealing with new apparatus and the technical publications of manufacturers of interest to our members. There is also room for improvement in the quality of the paper and illustrations used in the JOURNAL. Possibly an increase in the page size would add to its legibility.

There is much work ahead for the Projection Theory Committee. Problems requiring investigation and study include those of possible eye-strain produced by the motion picture, the merits of non-intermittent projection for two-color additive photography, and the possibilities and limitations of rear screen projection.

The work of collecting historical apparatus and the placing of this in a permanent depository needs to be pushed forward more actively in the east. The problem is to find some individual who is sufficiently enthusiastic and can afford to make it a labor of love. There should be duplicate exhibits in both the east and west—the donor should stipulate where he wishes the apparatus exhibited—and a replica or photograph should be placed on record in the complementary depository. I cannot emphasize too strongly the importance of establishing such exhibits and museums because apart from helping to prevent bogus patent applications, they would constitute an ever-present stimulant for new ideas. Our Society should also keep in mind the desirability of establishing a library at its headquarters.

There is need for additional committees to deal with safety problems, laboratory processing, theater construction and equipment, and an inter-society relations committee consisting of representatives of societies having interests cognate to our own. This committee should report on those activities of these societies which may be of interest to our members. I have in mind societies such as the Acoustical Society, the Optical Society, the Institute of Architects, and the Institute of Radio Engineers. The possibility of holding joint meetings with some of these societies should also be considered.

Our Society has always coöperated closely with the American Standards Association, the International Congress of Photography,

and the Deutsche Kinotechnische Gesellschaft, but the scope of these contacts should be enlarged.

The Society of Motion Picture Engineers should eventually be the principal medium for stimulating, collecting, and coördinating the technical and scientific knowledge in the motion picture industry, but this goal can be attained only by greater centralization of the Society's activities under the stimulating guidance of a permanent officer.

In this, my valedictory, I should be ungrateful if I did not remind you of the loyal support which I have received from your Board of Governors and the consistent efforts of the various committee members and committee chairmen who have given unsparingly of their time and energy in the interests of the Society. I especially wish to thank our Treasurer, Mr. H. T. Cowling, for his valuable counsel and undaunted encouragement during my administration.

J. I. CRABTREE, *President*

PROGRESS IN THE MOTION PICTURE INDUSTRY*

Summary.—*This report of the Progress Committee covers the period May, 1931, to September, 1931. The important advances in the cinematographic art which are described are classified as follows: (1) Production, (2) Distribution, (3) Exhibition, (4) Applications of Motion Pictures, (5) Color Photography, (6) Amateur Cinematography, (7) Statistics, (8) Publications and New Books.*

A conscientious effort was made in all branches of the industry during the past summer to stabilize existing equipment and to utilize present knowledge most effectively in improving the technical quality of the picture. It was known to be an established fact that sound of a high quality can be realized in master prints made under the critical scrutiny of studio technicians. The problem facing the industry is to get sound pictures of this quality into the average theater. Technicians were becoming more familiar with apparatus for noiseless recording. The introduction of such apparatus and the improvement in photographic emulsions are considered by members of this Committee to represent the two most outstanding developments of the year.

The cameramen placed their stamp of approval on the faster emulsions after several months of actual use. Cumbersome camera housings were gradually being replaced by more compact designs and mechanisms were being silenced so that the indications are that the sound camera of another year will resemble largely in external appearance the silent camera of a few years past. Sound technicians, however, were not as enthusiastic about their recording films of greater sensitivity as the cameramen, and an evident need exists for emulsions better capable of recording the higher frequencies of sound. A non-intermittent camera, of improved design, was introduced early in the year and seemed to be finding some application.

Studios throughout the world appeared to be favoring incandescent lighting over arc lighting, especially since it was possible to use less light with the introduction of high speed emulsions.

Useful instruments were made available for accurate measurement of sound intensity and reverberation, on studio sets and in theaters.

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* October, 1931, Report of the Progress Committee. Presented at the Fall, 1931, Meeting at Swampscott, Mass.

The details of construction of light valves and microphones underwent further improvements, rendering their operation more efficient. An increased use of portable sound recording equipment was prevalent rather than the use of installations which limited the movements of the actors and the cameraman. The re-recording of pictures for foreign distribution was becoming a necessity to retain export business in the face of improved sound picture production in other countries.

The quality of release prints was studied carefully by a committee of technicians, which began the work of formulating suggested ways of raising the standard of quality. Laboratories found no difficulty in adapting themselves to processing the faster negative emulsions. During the past year, a large investment was made in building several new laboratories which were fitted with the most modern equipment for film processing. There is an evident trend toward greater refinement in laboratory work which has great significance for future quality. Several improved types of printing and editing equipment were in use for handling sound and picture records and for bipack color negatives.

Valuable recommendations were made by committees of this Society on the plan of projection rooms, improvements in projector design, monitoring of sound in theaters, and general maintenance of the projection room. Useful data were also published by a committee dealing with the subject of projection screens. Additional sound projection equipment operating on alternating current was made available for small theater installations. Further modifications were effected in details of sound reproducing apparatus, notably a substitution of caesium for potassium photoelectric cells. Anastigmat lenses were made available for projection.

The number of projectors using sub-standard film continued to increase, and a project was being organized by several large manufacturers of motion picture equipment to make and distribute such apparatus for educational and business purposes. Television broadcasting stations increased in number throughout the world. Improved apparatus for scanning the subject was described, which, it appeared, would be effective in minimizing some of the difficulties of this phase of the problem. Greater knowledge of the characteristics of rapidly moving phenomena was made possible by the construction of new cameras for recording such motion.

A new three-color screen process was demonstrated in England.

Better definition in a two-color subtractive process was claimed by its proponents, but commercial work in the process continued to be small compared with a year ago. A lenticulated film process for the ciné amateur was announced by a German manufacturer.

Acknowledgment.—Valuable data on illumination conditions in British studios were made available to the Committee by W. A. Villiers, who submitted a copy of a paper which he read at the International Illumination Congress held in London in September. Other useful material on progress in England were received from W. Vinten and E. Lauste. Additional information of value was supplied by H. E. Edgerton, H. H. Strong, J. T. Wilson, and N. D. Golden. A very comprehensive report on developments in Japan was prepared by a member of this Committee, formerly residing in Osaka. Data prepared by A. I. Ward, U. S. Consul at Tientsin, China, have been edited and are included as an appendix to the report. Several useful illustrations were made by A. Denis.

Illustrations were obtained from the following sources: American Motion Picture Machine Co., New York, N. Y., Cinema Patents Co., New York, N. Y., O. B. Depue, Chicago, Ill., Duplex Motion Picture Industries, Inc., New York, N. Y., Electrical Research Products, Inc., New York, N. Y., and Hollywood, Calif.; General Electric Co., Ltd., London, England; Mole-Richardson, Inc., Hollywood, Calif.; Mechanics Institute, Rochester, N. Y., Metro-Goldwyn-Mayer, Inc., Hollywood, Calif.; Prabhat Film Co., Kolhapur, India; United Artists Corp., Hollywood, Calif.; Western Electric, Inc., Los Angeles, Calif. Illustrations were also obtained through the courtesy of the *American Cinematographer*, *Cinéopse*, *Electronics*, and *Revue d'Optique*.

Respectfully submitted,

M. ABRIBAT	H. B. FRANKLIN	M. W. PALMER
L. BUSCH	J. G. FRAYNE	G. F. RACKETT
W. CLARK	E. R. GEIB	M. RUOT
A. A. COOK	A. C. HARDY	P. VON SCHROTT
C. DREHER	R. C. HUBBARD	H. SINTZENICH
R. E. FARNHAM	F. S. IRBY	S. K. WOLF

GLENN E. MATTHEWS, *Chairman*

SUBJECT CLASSIFICATION

I. PRODUCTION

A. Films and Emulsions

1. New Materials
2. Manufacture
3. Miscellaneous

B. Studio and Location

1. General
2. Lenses and Shutters
3. Cameras and Accessories
4. Special Cameras
5. Studio Illumination
6. Trick Work and Special Process Photography
7. Methods of Recording Sound
8. Set Construction

C. Laboratory Practice

1. Equipment
2. Photographic Chemicals and Solutions
3. Processing Technic
4. Printing Machines and Methods
5. Tinting and Toning
6. Editing and Splicing
7. Cleaning, Reclaiming, and Storage

II. DISTRIBUTION

III. EXHIBITION

A. General Projection Equipment and Practice

1. Projectors and Projection
2. Sound Picture Reproduction
3. Projector Lenses, Shutters, and Light Sources
4. Fire Prevention

B. Special Projection Methods

1. Effect Projection and Stage Shows
2. Portable Projectors
3. Stereoscopic Projection
4. Non-intermittent Projection

C. Theater Design and Installation

1. Screens
2. Theater and Stage Illumination
3. Theater Acoustics and Construction

IV. APPLICATIONS OF MOTION PICTURES

A. Education, Business, and Legal Records

B. Medical Films, Radiography, and Cinephotomicrography

C. Television

D. General Recording, Miscellaneous Uses

I. PRODUCTION

A. Films and Emulsions

Interest in the adoption of wide film, though dormant for the past six months, is expected to be aroused again with the return of normal economic conditions.[1] A tentative layout of a 50-mm. negative and release print was submitted to the Society by the Standards and Nomenclature Committee at the Hollywood meeting in May, 1931, for consideration. After careful tests made under the supervision of committee members, it was concluded unanimously by the committee that the proposed film has all the advantages of other wider sizes and in addition is more economical and less difficult to use.[2]

The high-speed panchromatic emulsions introduced earlier in the year have been given exhaustive trial under the severe working conditions prevailing in the studios, both in this country and abroad. General satisfaction has been expressed by the trade in regard to their characteristics. The American Society of Cinematographers in a published report has recommended their use,[3] and has stated that they present no problems in laboratory processing. Japanese cameramen have been more reluctant about accepting the new product, however, chiefly because film processing is still done largely by inspection in Japan. According to Marsh,[4] American cameramen feel

that the greatest advantage of the new film is not the increase of speed but the improvement of the quality of tone reproduction.

For many years, the problem of halation has faced cameramen, and with the introduction of panchromatic film, it became even more serious, for, according to Sease,[5] the gelatin-silver halide layer of such emulsions is much more easily penetrated by yellow and red radiation. One of the most effective ways of combating this trouble has been to coat the back of the film with some dye or dye mixture which will absorb the radiation. Huse[6] has described one such film which has the emulsion coated on a support having a neutral gray density of 0.2. As the gray backing is unaffected by any of the processing solutions, it is only necessary to increase the printer light, $1^1/_2$ to 2 points over that normally used.

While the new emulsions found ready acceptance for picture work, sound recording departments have not been so enthusiastic about some of the newer sound recording negatives that have been tried out on an experimental basis. These newer sound emulsions as a rule have shown only the single advantage of speed, without any improvement in high-frequency response to recorded sound vibrations. The resulting saving in exciter lamp current is an advantage, however, in connection with portable recording equipment.

According to reports from abroad, a German firm is preparing to market a new fast panchromatic emulsion of high-speed sensitivity to red radiation. In Japan, two different companies are planning to manufacture motion picture film in 1932. About 70 million feet of positive film is used annually in Japan and China and about 3 million feet of negative.

The manufacture and properties of film made from viscose have been discussed by Nauck.[7] Five patents were noted dealing with improvements in the manufacture of films for sound reproduction.[8] A trade note described a new film having a thin copper band over the perforation area to reënforce the film and prevent tearing of perforations.[9] Two patents were issued covering somewhat similar improvements.[10]

Production of color motion pictures continued to be small during the summer months, although there was an increase in color "shorts," and in the use of color for advertising or commercial pictures. Two expeditions were making color pictures, one in the Arctic and one in the Far East. Plans were announced for the construction of a laboratory for the processing of color films in Shanghai, China.

During the first week of August, the Eighth International Congress met in Dresden, Germany. At this important gathering over 100 papers were read by scientists from many countries. Proposals for standardization of sensitometric practice were considered and characteristics of safety film and international regulations for handling it were discussed.

B. Studio and Location

During the past six months, motion picture studios continued to make their sound recording equipment more portable and to bring the talking picture gradually to the same technical perfection as the old silent picture. Activity in most studios throughout the world was hampered considerably by the world-wide depression which continued throughout the summer. More feature sound pictures were made, however, at various English, French, German, and Russian Studios, than in the previous six months, some of which found an outlet in the American market. It was becoming increasingly more difficult for American sound pictures to be sold for foreign distribution without being re-synchronized in the language of the country where they were to be shown.

Production schedules in Japan, the largest producing country in the Far East, were almost as heavy as in previous years. Until quite recently,* it has been common practice in Japan to show two and sometimes three feature pictures and shows lasted sometimes as long as six hours. In order to supply the demand created by such exhibition schedules, a great many feature pictures were required. Last year 650 features were produced and this year almost as many were planned; a leading company, the Shochikur Studios had 6 special features, 20 monthly features, and 104 regular weekly productions under consideration. The five largest Japanese companies have an annual budget of about $18,000,000 and plan to make nearly 400 features. About 4000 persons are employed by the Japanese studios.

For many years, Kyoto has been the center of studio activity in Japan but at present several companies are locating in Takarazuka, and it appears that this city is to become the producing center of the Far East.

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* Feature pictures are now limited to 5000 feet (except for special features) and a show cannot run over 4 hours, during which not more than 6000 feet can be shown.

Lenses and Shutters.—A projection method of testing photographic lenses has been described by Rayton,[11] which consists in photographing the projected image of a small aperture placed at selected points in the image plane of the lens under test. Köfinger[12] has prepared charts showing the depth of focus settings and diaphragm openings for the 50-mm. Biotar $f/1.4$ and the 35-mm. Plasmat $f/2$ lenses.

Optical systems continued to be devised for producing a wide image on standard film. A process which is called "Fulvue," uses a cylindrical lens designed to magnify the scene in the horizontal plane only. The lens is used in the projector as well as the camera.[13] A French solution of this problem, according to Autré,[14] uses wide film negative in the camera, the images on which are reduced onto 35-mm. film during printing and are enlarged by a cylindrical lens when projected. The cylindrical lens is called the *Hypergonar.* It has 5 elements and was designed by Crétien.

A comparatively limited number of patents were issued dealing with lens design.[15]

Cameras and Accessories.—An aftermath of the initial introduction of sound pictures in 1928 was the adoption of camera housings of every conceivable design. These have served their purpose very well in most cases but they have also hampered the cameraman's efforts considerably, and have prevented the effective use of certain devices such as auxiliary view finders. Several suggestions for the solution of these problems were offered at the Symposium on Studio Practices held at the 1931 Spring Meeting in Hollywood.[16] Evident need for a greater standardization exists, particularly with regard to camera silencing. Preliminary replies to a questionnaire sent to 60 cameramen by the Producers-Technicians Committee of the Academy of Motion Picture Arts and Sciences indicated that over 91 per cent favored elimination of "blimps," 90 per cent condemned their excess weight, and 55 per cent stated that the housings made focusing difficult.[17]

Further details have been published on the Fearless camera dual magazine adapter since the last report, which indicate that the device is designed to take any of several types of magazines. Bi-pack films may be exposed easily with the use of the adapter.[18] The silent Mitchell camera, which was shown in the Apparatus Exhibit at Hollywood, has been described by Stull.[19] A slit mount replaces the more usual lens turret. An insulated hood mounting is used to enclose the motor. The Radio Corporation of America have an-

nounced the perfection of a silent 48-cycle camera motor which eliminates the necessity of gears between the motor and camera. They also announced a 720-rpm. silent camera motor for use on Fearless and Bell & Howell cameras.

Several improvements have been introduced on the German-made Askania Model Z camera to make it run more silently. The film channel and optical system have been changed to eliminate the chance of the image being thrown out-of-focus by mechanical injury to the camera. Special magazines are available, which adapt the camera for color photography by the bi-pack method or for trick work by the Dunning process. A time-lapse device has been designed which permits making automatic exposures of 20 seconds' to 10 hours' duration.[20]

Additional data have appeared on the Debrie Sound Film camera since the writing of the last report. Safety devices have been introduced, which prevent damage to the mechanism in the event that the camera jams. A sound absorbing case covers the entire camera. For studio use, a special metal stand is provided, which rides on three rubber-tired wheels. The cameraman stands on a small rear platform.[21]

One novel scheme for camera silencing in use at Educational Studios is a cast duralumin case (for the camera) from which the air is exhausted. It is claimed that the most sensitive microphone may be moved within two feet of the camera without detecting any camera noise.[22] An improved pilot pin mechanism was introduced by Bell & Howell for their cameras, which renders them satisfactory for use on sound stages.[23]

A light but very sturdy rolling tripod has been announced for use with Mitchell cameras. A single crank controls the camera height and permits the lens to be dropped a yard from the floor or raised 8 feet above the floor.[24]

Patent protection was granted on a number of disclosures on improvements in camera design.[25]

A motion picture camera which permits the photographing of phenomena which last only 0.00001 second was demonstrated in June before the French Academy of Sciences. A study of aerodynamics is contemplated.[26] Huguenard and Magnan[27] have designed a camera employing four lenses, which takes 12 pictures in an area the size of our standard 35-mm. frame. With a linear velocity of the film equal to 3 meters per second, 2400 pictures

may be exposed per second. Pictures made of the free flight of a large fly show that it beats its wings about 100 times per second, whereas a Senegalese linnet moves its wings only 30 times in a second.

Several descriptions have been published of the Moreno-Snyder non-intermittent camera which was exhibited at the Hollywood meeting in May, 1931.[28] The regular lens in this camera is supplemented by eight rectangular plano concave lenses which move with the film to correct its continuous movement. That the camera is capable of doing high-speed work was demonstrated this summer when wave motion of vibrating pools of mercury was photographed at a film speed of 1440 feet per minute without injury to any part of the camera. Even at this speed of over 400 frames per second, it was found that ample exposure was obtained on positive film with an $f/3.5$ aperture.[29]

The requisites of lenses for long distance photography have been discussed by Gramatzki.[30] Investigations made with apparatus for analyzing rapid motion have been dealt with at some length by Ende.[31] The movement of typewriters, gas engines, thermal regulators, electric arcs, *etc.*, were studied.

Only four patents were noted covering special camera design.[32]

Studio Illumination.—The past six months represented a period of stabilization in lighting equipment rather than one of development. Very few new pieces of equipment were introduced. An addition to the cast silicon-aluminum equipment announced in the previous report is a new spotlight employing a 2000-watt, 115-volt monoplane filament lamp. Increased efficiency and an actual saving of approximately $60,000 a year are claimed for the introduction of portable platforms for spotlight supports in the RKO-Pathé Studio at Culver City, Calif. The floor platforms may be raised or lowered by set screws and the planking has regularly spaced holes for bolting down the lamps. The ceiling platforms are hung to the rafters by means of chains.[33]

Villiers presented a paper on incandescent lighting in British Studios before the International Illumination Congress held in September. According to this authority, there has been a marked tendency to employ a greater proportion of incandescent lighting in nearly all studios, the average studio now using 70 per cent incandescent lighting. As a result of tests made on many different types of reflectors, polished aluminum has been adopted as most efficient, inexpensive, and of least weight. For general lighting, banks of lamps are com-

monly used with as many as 40 lamps in a unit consuming about 10 kilowatts. Matted aluminum reflectors are used for each lamp. (Fig. 1.) A 3-kw. spotlight is used most largely in conjunction with an 18-inch diameter parabolic mirror. Special treatment of the filament supports overcomes the troubles from blackening of the bulb. Heat from the lamps has been reduced considerably by using a special glass baffle which absorbs 50 per cent of the heat and only 15 per cent of the light.

Salmony[34] has prepared data on the performance of Osram lamps of 10- and 50-kw. capacity used in German motion picture studios.

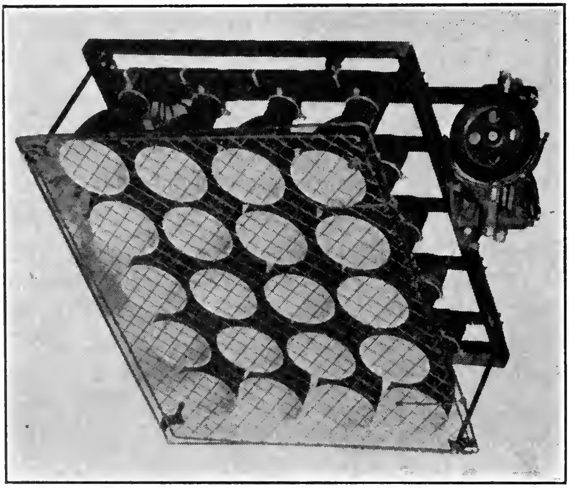

FIG. 1. Overhead lighting unit (20–500 watt lamps). (Reproduced by courtesy General Electric Co., Ltd. London.)

About 228,000 and 1,000,000 Hefner lumens, respectively, represent the output of these two types. Technical properties of the photoflash lamp and reflectors for its efficient application have been described by Farnham.[35]

Trick Work and Special Process Photography.—Considerable interest is being evinced by several of the West Coast studios in the recently revived process of composite photography which consists in photographing action in front of a large (ground) plate glass upon which is projected the desired background for the action. The shutter of the projector is maintained in synchronism and phase

with that of the camera. Patent protection on a few processes related to trick work has been obtained.[36]

Sound Recording.—Modern sound pictures, according to McNair[37] have necessitated many advances in acoustical engineering in order to control adequately the conditions under which the pictures are recorded. Actually every sound picture is an illusion and the problem has been so to record and to reproduce the illusion as to yield the greatest realism. Maxfield[38] has shown that an empirical relationship exists between the placement of the camera and the microphone, and the acoustic properties of the set. Some eight or ten pictures have been made using the technic, and the results were so well liked that a more general application of the principles is being made.

For the first time in the making of a sound motion picture, short wave radio communication was maintained between a ship at sea and the studio lot in Hollywood in the recent filming of the *Corsair*, a United Artists picture. While this was felt to be an innovation, it is believed the practice may become widely adopted, as it tends to speed up production on location.

Development continued to proceed rapidly in the field of sound recording. With a new intensity meter, it is possible to measure sound and noise intensities in sound stages and theaters. Levels from 15 to 100 decibels above the hearing threshold may be measured. The instrument is characterized by its compactness and lightness of weight. Livadary[39] has treated the effect of optical slits in different systems of recording. Advantages and limitations of one ribbon *versus* two ribbon light valves are discussed. Proper designs of flashing lamps have been dealt with by Braman[40] who devised a special three-electrode type in which the third electrode adjusts differences between ignition and extinguishing voltages. A paper by Ceccarini[41] on light valve technic was presented in Hollywood and has recently appeared in our JOURNAL.

A permanent magnet light valve has been devised recently by Western Electric in which the bulky electromagnetic field coil used in the previous type has been replaced by permanent pole pieces. The ribbons are clamped in position after the initial spacing and tuning operation. The valve is very compact when used in a studio film recorder. (Fig. 2.)

Satisfactory recording of frequencies up to 10,000 per second is claimed for the Fidelytone system of sound recording developed in England. An image of the cathode, consisting of a long metal strip

in an exhausted glass tube, is formed on the moving film, the light glow extending along the length of the cathode from the metal anode opposite its center point. The length of the glow varies in accordance with the modulated input of the tube.[42]

In a scheme devised by W. Vinten, of London, five camera motors may be controlled independently of the current source by using four 12-volt storage batteries to drive special rotary converters attached to the sound recorders. The machine generates 33 volts, 48 cycles.

A symposium was held early this summer by the Acoustical Society of America on microphone design and performance. Frederick[43]

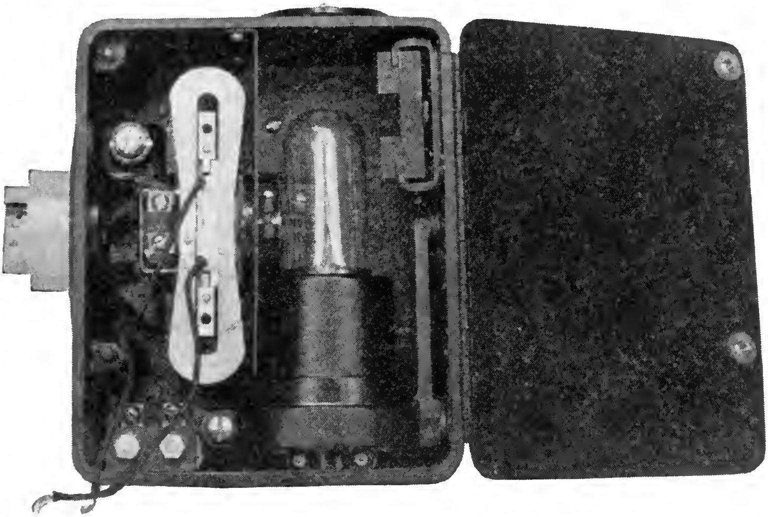

FIG. 2. Modulator unit showing permanent magnet light valve. (Reproduced by courtesy Bell Telephone Laboratories, New York.)

reviewed the development of this important adjunct for sound reception and showed that the condenser type has more recently displaced the carbon type of instrument. The moving coil type, however, was shown by Wente and Thuras[44] to have important practical advantages over the condenser transmitter; its sensitivity is 10 decibels greater and its response is uniform from 45 to 10,000 cycles. Olson[45] presented the theory of electrodynamic microphones, of which the ribbon microphone is an example.

According to a report from Hollywood, the Western Electric Com-

pany has introduced a new dynamic microphone which has an essentially flat response from 50 to 10,000 cycles per second. The Metro-Goldwyn-Mayer studio has introduced an innovation by placing the microphone and its associated amplifier in a spherical metal housing. This so-called "bomb" microphone is claimed to offer less distortion to sound waves than the more commonly used non-symmetrical housing.[46]

Livadary[47] has made a mathematical investigation of the distortion introduced in variable width recording by the finite width of the recording slit. An intensity method of recording sound employing cathode rays, has been worked out by von Hartel.[48] Advantages are: small inertia of cathode rays; small size of recording apparatus; and elimination of amplification.

At the Hollywood meeting, MacKenzie[49] presented data giving a comparison of the quality of sound records wherein the toe and the straight-line portion of the characteristic curve were used wholly or in part for making the negative and positive. Kellogg and Batsel[50] described a shutter for use in reducing ground noise. Methods for reducing noise were described by Kreuzer[51] in connection with variable width recording.

A noticeable trend is developing toward the use of portable sound recording equipment which can be operated economically even at some expense of quality, especially where sound is not considered to be of primary importance in telling the story. Felstead[52] has published details on several types of portable recording apparatus. Some types are installed in trucks for rapid transportation from one location to another; other units employ portable monitors mounted on rolling platforms. The Klangfilm Company of Germany has made a compact set of recording equipment, according to Freese and Lichte,[53] for use on expeditions.

The great importance that re-recording is assuming in sound motion picture production was stressed in the previous report. Two papers on the subject were presented at the 1931 Spring Meeting. In one of these Kuhn[54] described a new re-recording machine which possessed several novel features. Dreher,[55] in the other paper, dealt more generally with the subject, showing how sound engineering, re-recording, and editing must be coördinated closely for obtaining best results in the finished picture.

Re-recording has assumed a new importance in connection with the dubbing of foreign language versions with original American

action pictures. Electrical Research Products, Inc., has reported that extensive use is now being made of the special re-recording machine which was described by Kuhn. A greater refinement is possible with this device than could be attained by the older projection method. Since there is no aperture plate, no emulsion or foreign matter can accumulate and throw the film out of focus.

Kutzleb[56] has described three systems for synchronizing speech and pictures in German studios. One item on the annual technical report of A. E. G. for 1930 was a description of a new German re-recording apparatus. Three films may be passed through the device simultaneously and the record made on a fourth film, or on a disk.[57] In a paper delivered before the International Congress of Photography in August, Thun analyzed the factors which must be considered for satisfactory after-synchronization.

Straight-line reproduction is claimed by Rothy[58] to be obtained with selenium cells by introducing several tuned oscillatory circuits into various stages of amplification. The output from a selenium cell with a hook-up of this kind is said to be about 200 times greater than from a photoelectric cell combination. Roth[59] has published further details on the *Selenophon* recording and reproducing process mentioned in the last report.

Two valuable surveys of patent literature with reference to vacuum tubes, receiving circuits, *etc.*, have been published.[60] A fairly large number of patents have been issued dealing with improvements in sound recording.[61]

Set Construction.—It has long been recognized that a pure white fabric introduces high contrasts which are difficult to reproduce satisfactorily in motion picture work. Common practice in studios has been to use a pale tinted fabric instead of pure white for table cloths, dress shirts, *etc.*, but no effort at standardization of tint was made by the various studios After careful tests, Miller[62] proposes a pearl gray, known as "Pickford Gray," as most suitable, particularly with the new high-speed panchromatic emulsions.

Greatly enlarged prints showing characteristic views of New York have been mounted and placed behind windows in studio sets to serve as backgrounds to scenes in recent productions.[63]

The use of two rotatable circular stages one within the other on which players and cameras are placed, respectively, has been patented.[64]

C. Laboratory Practice

Equipment.—Development of negatives by machine has become almost universal practice. The introduction of the faster emulsions, however, has necessitated more careful handling of film in the darkroom. A tendency to overexpose negatives is said to be prevalent, with accompanying loss in quality, but as cameramen rapidly become acquainted with the newer materials trouble of this type will quickly disappear.

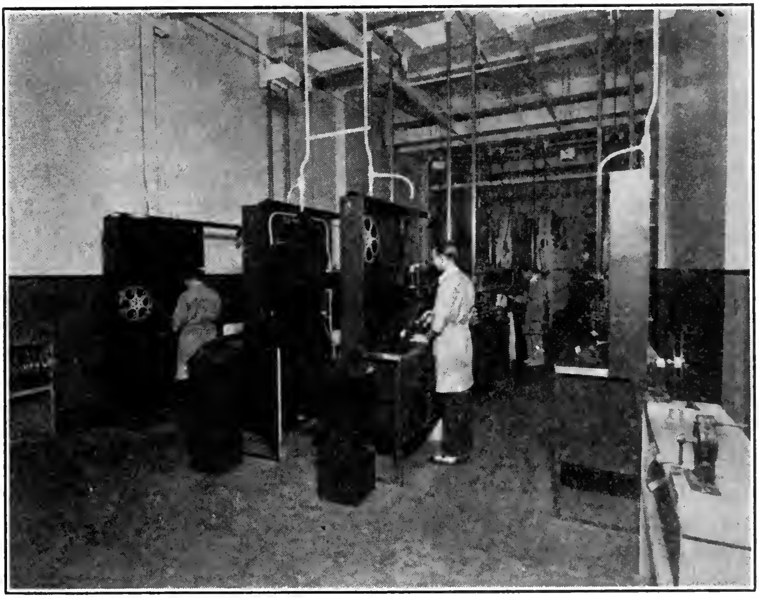

FIG. 3. Automatic negative developing machines. (Reproduced by courtesy J. M. Nickolaus, Metro-Goldwyn-Mayer, Inc., Hollywood.)

One of the most recent additions to the list of modern laboratories is the new M-G-M Laboratory in Hollywood. All film is processed on machines, of which there are twelve, and only that actually being handled is exposed, as all other film is stored in self-closing steel lockers. The maximum capacity of the laboratory is 300,000 feet of negative and 4 million feet of positive per week. Each developing machine is a distinctly separate unit, from the mixing tank and chemical room at one end to the dryer at the other. (Fig. 3.) Solutions are fed to the machines by gravity, and are circulated at about

15 gallons per minute. All twelve machines may be operated independently of each other. There is automatic temperature control of developer solutions and air in the rooms. Silver is recovered electrolytically from the fixing baths. Two papers describing the silver recovery installation were presented at the Hollywood meeting by Hickman and co-workers.[65]

A new friction feed processing machine has been devised by the Cinema Patents Company. The film moves vertically in each of a series of developing, rinsing, fixing, and washing tanks. In the positive film machine, the film moves 125 feet per minute. A new type of patented bottom drive is used.

As noted previously in this report, the Multicolor Company, Ltd., has announced the construction of a color laboratory at Shanghai, China.

For the convenience of motion picture companies, the Technical Bureau of the Japanese Railway is fitting up three cars so that film may be developed and printed *en route*. Projection facilities are included.

The Eastman Type 2-B sensitometer, which was exhibited at the 1931 Spring Meeting is reported to be in use by several of the West Coast studios and laboratories.[66] A new densitometer has been offered the trade by Electrical Research Products, Inc. This instrument measures diffuse densities up to 3.5, with errors of not more than 2 or 3 per cent. Light transmitted through the area on the film to be measured is compared with an uninterrupted beam through an ocular. Densities may be read either directly or minus the fog density.

Bluhm[67] has described a new type of photometer which is entirely objective in operation. It consists of a photoelectric cell connected in circuit and fed by a 4-volt battery. The instrument is calibrated to read directly in lux. Besides its use for measuring negative density, it is recommended for determination of studio light intensity and for measurement of screen illumination.

Ives, Miller, and Crabreee[68] dealt with several miscellaneous improvements in laboratory apparatus at the Hollywood Meeting.

Photographic Chemicals and Solutions.—Lobel and Dubois[69] have published two papers on the subjects of measurement of the sensitivity and the determination of development time, respectively. In the first article, emulsion speeds were expressed in terms of relative exposure according to four different systems, and a conclusion is

reached that practical tests give the longest exposure values. In the other paper, it is recommended that the Walkins factor should be used more in practice to attain definite gammas. A method of sensitometric control in the development of variable density sound films has been described by Küster and Schmidt,[70] which utilizes an exposure box and a gamma meter.

A comprehensive paper was presented before the International Congress of Photography by Dziobek on the use of the tungsten vacuum lamp in sensitometric measurement. It is concluded that the use of such a lamp, with certain reservations, represents a practical unit of intensity.

A controversy has raged in Europe during the past year around the claims made by Neugebauer that the use of a desensitizer seriously decreases emulsion speed. Emmermann[71] summarizes the opinions of various workers and concludes that the speed decrease exists, but that it is so slight as to be of little practical interest, and that a slight increase in development time will compensate for it. Huse considers the use of a desensitizer to be unnecessary in modern machine development practice and to be avoided for rack and tank development except as an emergency measure.[72]

Robin[73] has published the results of a study of certain photographic reducers.

Processing Technic.—A general paper stressing the importance of temperature control during film development has been prepared by Thorne-Baker.[74] Combined development of sound track and picture has been discussed by von Hartel.[75] In connection with processing technic, reference should also be made to the important paper by MacKenzie on straight-line and toe recording mentioned under the section on "Sound Recording."

Printing Machines and Methods.—For some time, the American Society of Cinematographers, in conjunction with the Academy of Motion Picture Arts and Sciences, has been conducting an investigation on the quality of release prints. Although the formal report on the investigation has not appeared, Arnold[76] has published an article giving the preliminary results of this investigation. Laboratory processing of negatives and master prints is quite satisfactory but evidence exists that much of the quality is lost in the preparation of release prints, on which the public judges the value of the entertainment of a picture. Recommendations are being drawn up to correct this serious production defect.

A new printer for simultaneously printing sound record and picture was exhibited by Bell & Howell at the Apparatus Symposium held at the 1931 Spring Meeting.[77] A feature of this device is the use of a traveling matte, moving between the negative and the printing light, which controls the printing value of the light and dispenses with notching the film. Recommended operating speed is 60 feet per minute. Changes are being made to adapt the printer for daily work. This company has completed erection of a new building at Hollywood which will provide service departments for both professionals and amateurs.

Several other manufacturers offer new printing equipment, though details of construction are somewhat meager. Depue, of Chicago, has announced a 35-mm. combination sound and picture printer, as well as an intermittent printer for color picture work. Duplex Motion Picture Industries, of New York, also has introduced a combined picture and sound printer, as well as equipment for handling bi-pack negatives.

The sound printer moves continuously, and uses two rheostats for controlling the printing light. Sixty scene changes are possible with the sound track and 150 with the picture. The color printer is driven intermittently and prints on both sides of double coated stock simultaneously. Pilot pins are used for registration.

Two companies are stated to be supplying improved types of light change devices for printers.

According to reports from the processing laboratories, the improved quality of duplicating emulsions now makes it possible to prepare duplicate negatives of a quality such that an expert can hardly recognize them from original negatives. Duplicates are being made of newsreel negatives, effecting an important saving of time in this field of work. Variations in density contrast are corrected in the duplicate so that no change of light in printing is necessary for sound or scene.

A note in the English publication *Bioscope* states that the Standard Kine Laboratories have installed apparatus for working the Hepworth "stretched" negative process. Films taken at 16 pictures per second can be "lengthened" and subsequently projected at higher speeds. It is claimed that "slow motion" films can be made by this method from normal negatives.[78]

In connection with the study of the shape of the curve of a variable width sound record, Weinglass[79] proposes to move a narrow beam of

light of definite length across the sound records. The variation in integrated transparency is expressed as a function of the curve of the record.

Patents for printing machines dealt, among others, with methods of varying the light, obviating intermittent motion of the film, printing from wide film onto narrow film, *etc.*[80]

Tinting and Toning.—Brock[81] has described the advantages of selective hand-coloring of motion picture films and presented details of equipment used for this work.

Editing and Splicing.—Many improved types of equipment for editing sound film have been introduced in the past year. A rewinder for cutting bi-pack negatives and an accompanying sound record to match an accepted positive has been described. Four reels are mounted on a common shaft and all four films are rewound until a splice is reached on the print whereupon the negatives are cut to match.[82] A new model Bell & Howell splicer for 35-mm. film is equipped with disappearing pilot pins, for splicing 16-mm. film. Other features are: a new style cutter, and a heating unit maintaining a constant temperature in all parts of the machine with which the film comes in contact.

A cleaning and rewinding machine has been marketed which is claimed to detect breaks, tears, or poorly made splices, and at the same time remove oil and dirt from the surface. It runs at 250 feet per minute.[83]

Several accessories manufactured in Germany have been described in a recent issue of *Kinotechnik*. The chief ones mentioned are a sound film cutting and editing table; a sound splicing block, and a switch for darkroom lights.[84] A special punch for editing sound negatives punches a triangular hole in the negative sound track which prints an opaque area on the positive. A method of marking splices for identification is also described.[85]

Two patents on editing equipment were noted.[86]

Cleaning, Reclaiming, and Storage.—The importance of preservation and storage of films used by educational institutions has been stressed by Rahts,[87] who cites the hazards of using nitrate films. Proper technic for handling and storage of film is described. Norling and Rippenbein[88] have dealt with a method of treating film for elimination of abrasions and improving elasticity. The method is stated to involve swelling and contraction with a subsequent glazing of the surface.

A series of tests made on film by representatives of the National Board of Underwriters were described by Fowler and Newell.[89]

Only four patents relating to methods of cleaning and reclamation of film were issued.[90]

II. DISTRIBUTION

Efforts at standardization of release prints have greatly reduced the need for cue sheets, according to reports from exchanges, and it is likely that their use will eventually be abandoned. Richardson[91] advocates the shipment of films to exhibitors in 2000-foot rather than 1000-foot lengths. The practice of splicing the 1000-foot lengths, rewinding onto 2000-foot spools and separating again, seriously interferes, in time, with the continuity of scenes between reels.

III. EXHIBITION

The idea of a chain of small theaters, showing chiefly newsreels or shorts, appears to have been abandoned except in the largest cities. These theaters apparently attract a patronage composed chiefly of transients, and at best have only a novelty value. A unique playhouse of this type opened in August in Los Angeles. Front projection was used, turnstiles were introduced, and photoelectric cells were employed in several unique ways such as to open doors, turn on drinking fountains, *etc.*

A. General Projection Equipment and Practice

No improvements of any importance were noted on standard projectors of American make since the previous report, although several types of portable projectors were made available. The Ernemann III, manufactured by Zeiss-Ikon, has several interesting features worthy of comment, namely, an $f/1.9$ lens, a film gate shutter, a mirror arc fitted with a 250-mm. mirror, and an improved film track insuring constant positioning of the film in the gate.

Unperforated Ozaphane film was projected on a Cinelux projector at a meeting of the French Société de Photographie held this summer. Although the facilities did not permit reproduction of the recorded sound, it was reported that the demonstration otherwise was successful. Framing of the unperforated film was accomplished by projecting light through images of perforations (printed along one side) onto a selenium cell connected to a one-tube amplifier. The current acts on a small relay which works a magnetic clutch, which, in turn,

actuates a framing lever. The film surface is protected by a varnish. Splicing is accomplished by treating the surface with a normal zinc chloride solution at a temperature of 140°F. (60°C.). The film thickness is 0.05 mm.

Before films may be projected in Japan, the exhibitor must supply the police with a complete synopsis, including the exact words used in every title, or, if a sound picture, the exact words spoken by every actor. The remarks of the official "Benshi," or public announcers, must also be transcribed for the police report. Effective April 21, 1931, the projector speed cannot exceed 28 meters per minute for sound pictures, or 24 meters per minute for silent pictures.

Although no new apparatus was announced for projection, a large number of patents were granted on various accessories and apparatus.[92]

Sound Picture Projection.—While there has been some improvement in the quality of reproduced sound in the better type of theater, during the past year there has been no radical improvement in the devices or in the method of reproduction. A definite effort appears to have been made to improve the acoustics of the larger auditoriums, and sympathetic handling by the better type of projectionist has been apparent. Very slight improvement, if any, has been noted in the quality of sound reproduced in smaller theaters. This may be explained as a result of the recent year of depressed business, and with an upturn it is expected that there should result a greater effort in meeting this problem.

Sheridan[93] has published several installments of a series of articles dealing with prevention of interfering noises in sound reproduction. A test sound film having two sound records but no pictures has been made available for checking sound quality in the reproducer equipment. The two sound tracks are recorded from opposite ends thus making rewinding unnecessary.[94]

Sound projection has been added to the curriculum of the Working Men's College in Melbourne, Australia, where a theater with the necessary equipment has been made available.[95] The first Japanese sound pictures were produced during the past six months by two different companies. Disk recording was used. There are now 60 theaters equipped for sound in Japan. Eleven different systems are known to have been used in these installations. Extensive introduction of sound pictures is hampered, however, by the attitude of the Benshi, or professional announcers, who are regular members of

the staff of every theater. The general practice has been to reduce the volume of the sound sufficiently so that the Benshi can be heard, with the result that very often the sound is cut out almost entirely.

At the May, 1931, Meeting, Cunningham[96] described an a-c. operated reproducing equipment designed for theaters seating 1000 persons or less. This use of a-c. equipment for small theaters appears to

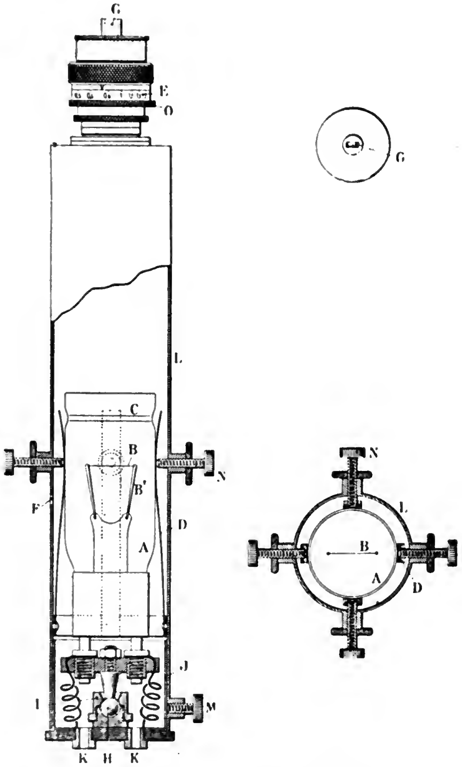

FIG. 4. Diagram of lamp for slitless sound reproduction. (Reproduced by courtesy L. Dunoyer and *Revue d'Optique*.)

be increasing as other types of power supply units have been made available. One concern announced the manufacture of a power filter unit designed to supply noiseless non-pulsating d-c. power from an ordinary a-c. line.

Back-lash rustle common to condenser loud speakers is said by Edelman[97] to have been eliminated in a speaker built of flexible im-

pregnated cloth carrying a conductive coating. Bostwick[98] has published details on a short exponential type of loud speaker which gives a uniform response from 60 to 10,000 cycles. Greater accuracy of measurement of response, especially in the low frequency range, is claimed by Olney[99] to result when tests are made out-of-doors.

A lamp for slitless sound reproduction has been devised by Dunoyer,[100] who has published a comprehensive mathematical treatise on its design and application. Essentially, the lamp consists of a cylindrical glass bulb having a flat piece of optical glass sealed in one end exactly parallel with a tungsten filament 25 mm. long and 0.1 mm. diameter. (Fig. 4.) The filament is made in such a way as to be perfectly rectilinear at its normal temperature of 2290°K. The image of the filament falls on a triplet anastigmat lens which, at a magnification of 8, gives a scanning zone 3 mm. in length by 0.0125 mm. in width.

Equipment has been made available for maintaining input power through the sound amplifier at a constant voltage. It consists of an autotransformer with an indicator. Hart[101] has written on the use of an oscillograph for volume control in sound film projection.

A substitution of caesium for potassium photoelectric cells continues, and it is expected that by 1932 equipment supplied by one of the large companies will use the caesium type almost exclusively. Reports from Europe indicate that improved types of gas-filled caesium cells are also available for use in sound studios abroad. Improvement in thin caesium photoelectric cells has been treated by Asao and Suzuki.[102] Treating the surface of the alkali metals with vapors of dielectrics such as sulfur or organic dyes has been shown, according to Olpin,[103] to improve the selective sensitivity of the alkali. Asada, a member of the Shiomi Scientific Institute of Osaka, Japan, has invented a super-sensitive grid "beam-tube," which is a combination of a photoelectric cell and a three-electrode vacuum tube. The grids are coated with a mixture of barium and cerium oxides, which improves their sensitivity. The device is stated to be 10,000 times more sensitive than the usual potassium cell.

Barton[104] has discussed the reasons for the development of the present power output tubes. An instrument for the measurement of the output of amplifiers, called an "audimeter" has been described by Hatschek.[105]

Numerous patents were issued which disclosed improvements in sound reproduction apparatus.[106]

Projector Lenses, Shutters, and Light Sources.—Data on new projector lenses are very meager for the past six months. An article has appeared describing the characteristics of the Super Cinephor lenses which were exhibited at the Equipment Symposium held in conjunction with the 1931 Spring Meeting.[107] These lenses are corrected for astigmatism as well as for spherical and chromatic aberration. A central definition is claimed equal to that afforded by prevailing types of lenses in addition to flatness of field. Martin[108] has analyzed some of the causes of condenser breakage and recommends polished edges of round or "V" shape as a means of minimizing this loss.

At the Eighth International Congress held in Dresden in August, Joachim presented a comprehensive paper dealing with optical systems for projection. Whereas some years ago the only object of manufacturers appeared to be to attain as much screen brightness as possible, nowadays the problem is to conserve electric current and at the same time secure maximum brightness. Recent 20-ampere lamps produce greater brightness than the older lamps using 80 amperes.

Only a few patents were noted dealing with projector lenses and shutters.[109]

The development of portable screen projection equipment using a porous screen eight to twelve feet wide, has created a need for a portable source of illumination of greater brilliancy than heretofore available. An effort to meet this demand is indicated by the introduction of a new low-current projector lamp designed to operate on 115-volts a-c. at a maximum of 15 amperes. A compact portable full-wave rectifier provides direct current for its operation. Automatic trimming is afforded by a differentially wound motor.

The properties of low-intensity reflecting arc projector carbons were discussed by Joy and Downes[110] at the 1931 Spring Meeting, who pointed out that with the faster projection lenses now available, together with a change in the magnification of the reflector system, a 75 per cent increase in screen light is theoretically possible. Screen illumination up to 140 and 150 foot-candles is claimed by Champion[111] for a new series of low-intensity carbons and slightly modified equipment.

As a result of an inquiry into visual fatigue conducted throughout twenty-seven Italian provinces, de Feo[112] found that 29 per cent of the 13,000 school children normally experience visual fatigue after

viewing motion pictures. Opinions of specialists on the subject are quoted, and all are in general agreement that well managed presentations do not cause eyestrain. Conditions favoring fatigue are listed. In another article, the same author recommends that programs for children ought not to last longer than 10 to 15 minutes without a rest period.[113]

Kögel[114] has discussed eyestrain in the viewing of motion pictures as caused by various involuntary movements of the eyelid and eyeball, and concludes that sound films strain the eyes more than silent pictures.

Fire Prevention.—A significant paper on the subject of handling film to minimize fire hazards was presented by Fowler and Newell at the 1931 Hollywood Meeting, as mentioned under the section, "Cleaning, Reclaiming, and Storage." A fire-proof film cabinet accommodating eight 2000-foot reels was shown at the Apparatus Symposium held at the 1931 Hollywood Meeting.[115] Several patents have appeared related to the subject of fire prevention.[116]

B. *Special Projection Equipment*

Effect Projection and Stage Shows.—Fulgara[117] has patented a scheme for projecting two lantern slides to serve as backgrounds for a projected motion picture.

Portable Projectors.—The growing field for portable sound projectors requires dependable, fire-proof equipment of limited size and weight. Dunsheath[118] has described an addition to this field, which has an automatic switch which turns the light on only when the mechanism has attained normal speed, and switches it off in case the film breaks or runs out. Light passing through the sound track is directed through a hole in the projector case onto the photoelectric cell in the amplifier case. A portable projector for sales demonstrations and other non-theatrical purposes has been announced by RCA Photophone, Inc. The equipment fits into four cases weighing 190 pounds, and operates on any standard a-c. source.[119]

At the 1931 Spring Meeting, Griffin[120] described a new portable sound projector which uses either a T-20, 900-watt, or a T-20, 1000-watt lamp. All operating parts are connected directly to the motor. A sound gate without tension shoes is used. The revolving shutter is located between the light source and the aperture. The equipment weighs 1000 pounds. A shaft driven portable sound projector for

use in auditoriums seating 800 persons has been described. A picture 9 by 12 feet may be projected.[121]

Comparatively few patents were issued during the past six months dealing with portable projectors.[122]

Stereoscopic Projection.—Since the writing of the last report Ives[123] has published a technical paper giving full details of his method of projection of parallax panoramagrams, using pictures made with his moving lens camera, and a screen made up of vertical, cylindrical celluloid rods.

Two patents were issued by the U. S. Patent Office on methods of securing motion picture exhibiting relief.[124]

Non-Intermittent Projection.—Further optical and mechanical details on the Gaumont "Simpliciné" projector have been published since the apparatus was described in the report of this Committee a year ago. This is a portable, non-intermittent projector of very simple design.[125] Advantages of the prism type of non-intermittent projector have been discussed by Plank.[126]

A non-intermittent projector for very thin (cellophane) film was demonstrated successfully in Madrid, Spain. The film has a row of performations along one side and the sound track is printed along the other border. Since the film moves continuously, the sound record does not have to be displaced from the picture but runs alongside each picture. Conical rollers pick the film from the center of each roll, thus avoiding the need of rewinding. The projector is known as the Kinisophote.[127]

A general review of the subject of non-intermittent projection has appeared in *Filmtechnik*.[128] A few patents have been noted.[129]

C. *Theater Design and Installation*

Screens.—A new sound screen, recently demonstrated in London, consists of a special fabric upon which small semi-parabolic lenses $^3/_8$ inch in diameter are mounted with a special light reflecting cement. The spaces between the lenses are cut away. A screen 22 feet by 17 feet carries about 460,000 lenses. Improved picture quality and increased screen illumination are claimed.[130] A new type of metal mesh screen has its surface chemically treated to render it free from all gloss. A clear view of the picture is claimed possible from any angle of observation. The surface is washable, and spraying outfits for resurfacing are to be loaned to the purchaser for a period of ten

years.[131] Ufa has produced a new screen for sound reproduction which is said to have a reflection factor of 94 per cent.[132]

Desirable properties of motion picture screens were discussed by Falge[133] at the 1931 Hollywood Meeting. Schering[134] believes that greater economy of current could be achieved in the smaller German theaters by the use of automatic feeding devices for the carbon arcs. Data obtained by him for several theaters having porous screens for sound film projection indicated a visual brightness far below the required value.

A sound permeable screen forms the front of a closed chamber having a back board carrying one or more sound reproducers according to a British patent recently issued.[135]

Theater and Stage Illumination.—The old massive switchboard in the wings of a theater stage has been eliminated, and in its place is found a compact control board with every circuit within reach of the operator. This has been made possible by the use of Selsyn control units comprising two small self-synchronous instruments. Low vacuum, arc-type, full-wave rectifying tubes, called *thyratrons* and air-cooled, saturable-core type reactors are used in conjunction with each Selsyn unit.[136]

Theater Acoustics and Construction.—Schlanger's unique plan presented at the 1931 Spring Meeting for reversing the slope of the orchestra floor, stirred up a considerable controversy and attracted widespread comment.[137] Schutz[138] believes that the scheme restricts the width of the auditorium close to the limits of the angle of good vision, but it has a beneficial effect in that it reduces the angle of projection. Another expressed opinion is, that it is doubtful whether the adoption of such a plan would result in comfort to the patrons. Most modern theaters are considered to have good sight lines and comfortable seating.

Ushers may now turn a dial at a sending station located in various aisles in a theater and acquaint the main foyer with the seating situation, giving the number and location of vacant seats. The new device will assist in seating waiting patrons quickly and without confusion.[139]

One of the world's largest theaters, the Gaumont Palace, in Paris, has been remodeled entirely and was opened again the past summer. The mezzanine and upper balcony, seating 900 and 1000 persons, respectively, are now carried without any visible supporting columns. A bridge resting on two abutments holds the entire weight of these two sections. The projection room is equipped with six projectors

and six lanterns, and requires about 3000 amperes at 110 volts. The total seating capacity is 6000.[140] In contrast to this huge theater, the first theater in each of two chains of midget theaters was opened during the past six months. Further installations will be restricted to the larger cities.[141]

A new type of acoustic material for correction of unbalanced absorption in theaters has been described by Schlenker,[142] who gives data on its use in several theaters and auditoriums. According to Glover,[143] a certain amount of reverberation is desirable in theaters since it reënforces the sound, but excessive reverberation changes the sound wave and makes speech unintelligible.

In a new type of reverberation meter supplied by Electrical Research Products, Inc., sound energy is converted into electrical energy, and a series of points is recorded on a waxed paper drum which gives graphically the exact history of the sound decay.[144] This instrument has found extensive use for the measurement of sound absorption coefficients.

IV. APPLICATIONS OF MOTION PICTURES

A. *Education, Business, and Legal Records*

Extensive plans are under way in Japan for expansion of the uses of motion pictures in education. Sub-standard film is now in wide use in the schools.[145] There are over 300,000 teachers in the empire's 45,000 schools housing 12 million pupils. A program of 180 pictures is in progress for school and general educational use under the direction of the Ministry of Education. Free cinema shows are arranged annually in cities and villages. Two leading newspapers in Osaka have assisted in organizing public interest and were instrumental in forming a "Society for Education."

In Milwaukee, Wis., a department has been established in a vocational school, where four teachers and an assistant supply all the films used in the school, a 600-foot amateur film being made every two weeks.[146] Eight thousand children viewed school films in Hawaii in 1928, which number increased to forty thousand in 1930.[147] An archive for important educational, cultural, and historical films has been instituted in Vienna.[148]

Tentative standards for city visual education programs have been reported by Enlow.[149] An empirical equation has been deduced for the average number of staff members of an adequate department.

Drawing or free-hand sketching from projected motion picture films is becoming more and more an accepted practice in art schools. (Fig. 5.) It is claimed to give the pupils a better conception of proportion, rythm, and perspective than static subjects. Commercial classroom films are now available for this work.[150]

Sound motion pictures have been offered as legal evidence of unpleasant noises, caused by an Australian dairy company's workman,

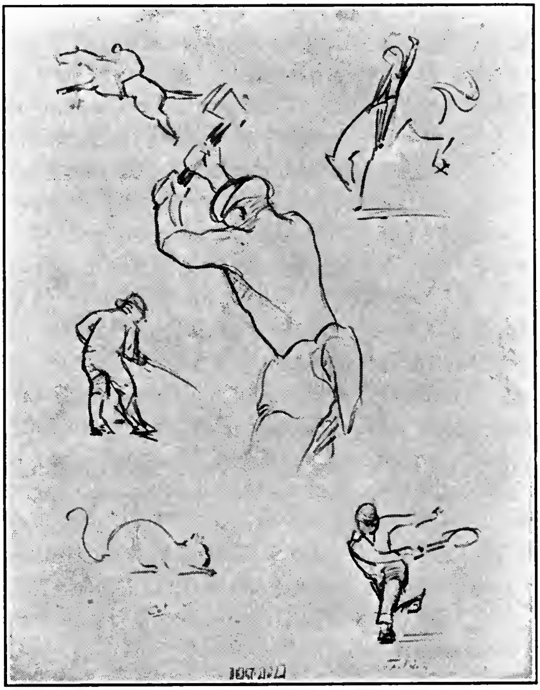

FIG. 5. Sketches made during the projection of a motion picture. (Reproduced by courtesy C. Ulp, Mechanics Institute, Rochester, N. Y.)

which disturbed the sleep of the plaintiff. In obtaining the record, a microphone was placed a few inches from the window-sill in the plaintiff's bedroom, and an ordinary voice recorded for comparison purposes.[151] In a new sound picture made during the past summer a typical order is traced through the New York Stock Exchange. The film will be available for showing throughout the country and abroad.[152] Manufacturers, whose goods are sold nationally, are to

make a series of sound films which will be shown in retail stores to stimulate trade in a scheme for business revival.[153]

B. *Medical Films, Radiography, and Cinéphotomicrography*

The best position of the camera for photographing surgical operations, according to Stout,[154] is directly above the operating table. A solenoid is used to start the mechanism of a sub-standard camera. The ordinary operating light was found sufficient for black-and-white photography but an extra lamp set-up was used for Kodacolor.

A very complete program of education in hygiene with the aid of films is under way in Soviet Russia.[155] The first use of motion pictures as an aid to psychoanalysis in the study of personality disorders and retarded mental development was reported at a recent meeting of the American Association for the Study of the Feebleminded in New York. Dr. L. P. Clark showed a film of the dramatization by two of his patients.[156]

At the recently held Eighth International Photographic Congress, Jacobson described the work which he and his co-worker Gottheimer have been doing in x-ray cinematography. Several films of heart beats, made by the indirect method, were shown.

Linke[157] has described the recently manufactured Askania camera for cinemicrography. Microscope, camera, and light source are mounted on independent supports. A 55-ampere, self-regulating arc is used, and available appliances make possible a range of exposures varying from 100 a second to one every 10 hours. Hardy and Pineo[158] have described a simple apparatus for cinéphotomicrography, their paper having been presented at the 1931 Spring Meeting.

Rosenberger[159] has patented an apparatus for making records of microscopic phenomena.

C. *Television Systems*

There are now 22 experimental radio stations licensed by the Federal Radio Commission, all but five of which are sending television programs on regular schedules. Ten applications for new stations were on file for a hearing in September, and at least twelve more applications were awaiting the Commission's inspection.[160]

Short[161] has published details on a television direct pick-up camera, in which the image of the person being televised is focused directly upon spiral number one of the scanning disk. Light passing through the disk takes the shape of a rapidly diverging cone and enters a

condensing lens system which concentrates it on a photoelectric cell. The camera is mounted on a rubber-tired truck which runs under its own power. Detailed movement of baseball games, tennis matches, and aeroplanes in flight have been followed easily with the apparatus, and it is possible to move quickly from a "close-up" to a "long-shot."

A demonstration of the Barthèlemy system of television has been described by Lovichi.[162] The transmitter employs a Weiller scanning disk, a horizontal wheel carrying on its periphery 30 mirrors inclined at varying angles to the axis. The scanning beam is reflected from these mirrors to the subject and then to the photoelectric cells. At the end of each cycle, the beam is interrupted a very short time. These lapses produce a 480-cycle frequency, which, filtered by an ingenious amplifying circuit, is used to operate a synchronous motor which drives the receiving scanning disk. A 3-watt neon lamp is used for a picture area of 600 sq. cm., as opposed to a 250-watt lamp for a 6 sq. cm. area in certain other systems.

A German television receiver serves for the reproduction of sound films, according to Winckel,[163] since it operates with 1200 picture elements and 25 pictures per second. The film moves continuously in the projector, which is used as a transmitter in connection with a Nipkow scanning disk. Broadcasting of sound films is being considered in Germany with the aid of this device.

D. General Recording and Miscellaneous Uses

Improvements effecting economies in steam boiler operation were made possible by studying motion pictures taken of the performance of a laboratory model made of glass. A mercury arc rectifier was also studied under conditions where direct observation would have been impossible. The operation of an automatic train stopping device was also filmed.[164]

Brackett[165] has published details on the use of sound pictures in the solution of solar eclipse problems. The United States Bureau of Mines Station near Pittsburgh, Pa., uses a film wound on a revolving drum to record the detonation of explosions and measure the duration and length of the flame path.[166]

Edgerton[167] has discussed the possibility of using intense intermittent light for motion pictures. A mercury-arc thyratron has been devised as the source of illumination, the frequency of which may be varied over wide limits. Stroboscopic motion pictures of the angular transients of synchronous motors have been taken with

the aid of this light source. Possible applications are the study of the claw mechanisms of high-speed cameras and projectors or the valve spring action of gas engines. Another possible application is the taking of high-speed motion pictures, which could be accomplished by eliminating the shutter and the intermittent motion of the film, and by arranging the light so that its flashes would occur once for each frame.

Experimental apparatus for the study of the phenomena of fuel injection in Diesel motors has been described by L. and A. Seguin and A. Labarthe.[168] The combustion chamber is provided with two windows, before one of which is placed a neon lamp of special design, and before the other an ultra-rapid camera. The successive exposures are recorded on a disk of film which revolves at high speed. The violet radiation of the spectrum of the neon lamp is enriched by a special arrangement which results in a considerable increase in its actinic power. Spark duration is of the order of a millionth of a second. A stroboscopic light is thus provided, permitting 20 to 100 pictures to be made at a rate of about 100,000 per second.

V. COLOR CINEMATOGRAPHY

While the past six months have been a very lean period for commercial color processes, there is now a definite trend toward making certain types of shorts and advertising reels in color as well as an indicated swing toward the production of feature pictures. General improvement has been shown in processes already developed and defects which were previously criticized with good reason have been eliminated. Directors and technicians faced many difficult problems, according to Franklin,[169] when color pictures were first introduced two years ago on a competitive commercial basis. Color should not dominate the picture, however, but when most effectively used, it should blend in with all other effects, acting, dialog, composition of scene, *etc.*, in order to enhance the general artistry of the whole.

A new additive screen process of three-color cinematography was demonstrated successfully before the Royal Photographic Society in May, 1931. The manufacture of the film has been described by Pereira,[170] who states that 1000-foot lengths of acetocellulose nearly 2 feet wide, are ruled with a three-color screen so that about a half million squares cover each 35-mm. frame. A coating of collodion stained green is put on the base and a greasy ink resist applied to the surface by means of an engraved steel roller. A bleaching bath then

destroys the green dye where it is not protected. A red line screen, and finally a blue screen are next coated in an analogous way, as the first screen. A special panchromatic emulsion of large sized grains is used as the last coating, so that on reversal of the negative, a fine-grained positive is said to be obtained. A projection method of making duplicates is said to have been perfected.

A limited number of patents were issued dealing with three-color additive motion picture processes.[171] The use of a lenticular screen film has been patented for the preparation of three separate color records to be used as matrices for the preparation of a final record.[172] Patents issued on two-color additive processes dealt chiefly with methods of projection.[173]

Better definition on long shots and freedom from grain on white areas during projection are claimed by Technicolor as a result of technical improvements in their process. Supersensitive panchromatic film has made possible a decrease in lighting necessary for exposure and increased the comfort of the actor as a result of the lowering of the heat from the lamps.[174]

Two interesting papers on the Multicolor process were read at the Color Symposium of our Society held in Hollywood this spring. Otis[175] gave details concerning the making of the pictures and Burns[176] described the new processing laboratory which was opened in 1930. A description of the Handschiegl and Pathéchrome processes was presented at the Symposium by Kelley.[177]

According to a patent by Didier,[178] a three-color subtractive motion picture may be made by printing on one side of a film an image made from the negative record exposed through an orange-red filter, toning this image blue, and then sensitizing thereon, from opposite sides, images from positives made with blue-violet and green filters. The two images thus formed in bichromated gelatin are dyed by applying paper strips soaked in dyes of the pinatype class.

Comparatively few additional patents were noted which dealt with subtractive color processes.[179]

VI. AMATEUR CINEMATOGRAPHY

A. General Equipment and Uses

A measure of the rapid growth of the amateur cine business is gained from a statement by Story that 300,000 projectors using 16-mm. film have been sold in this country, exclusive of those sold for narrower width films. More than 1000 productions in silent films

and about 400 pictures with sound-on-disk accompaniment are available for amateur showing.[180]

Irby[181] has discussed the supply and cost of 16-mm. film for home use, and concludes that successful exploitation of home talkies depends on the rental cost to the consumer. Present costs permit only a class market, but indications are that producer-manufacturer affiliations may result in a general lowering of costs with increased mass production.

Amateur motion pictures are becoming a very popular hobby in Japan, according to trade reports. Sound-on-disk equipment is available and Japanese-made 16-mm. cameras are being sold.

Amateur Cameras.—A British-made 16-mm. camera is fitted with a "trioptic synchronizing view finder," allied to which is a supplementary prismatic lens for use when taking close-ups. A triple lens turret is included, and the movement can be operated at five speeds, *viz.*, 8, 12, 16, 32, and 64 pictures per second. It is fitted with a Cinar $f/2.6$ lens.[182]

A new camera for 9-mm. film is equipped with detachable external film magazines of 150-foot capacity, as well as a standard magazine for holding 30 feet of film. Focusing is done directly on the film in the gate. A reverse movement is provided for dissolves and double exposures.[183]

Only two patents were issued describing improvements in amateur camera design.[184]

Projectors.—The new Model *K* Kodascope is equipped with a very efficient cooling system and an improved lighting and optical system. A 260-watt, 52-volt tubular lamp with a decentered filament is used. Moving the filament off the center increases the angle of light intercepted by the condenser. A rewind release and brake assures solid winding. A floor lamp may be plugged in on the projector so that it is turned on automatically when the projector lamp is turned off.[185]

A compact, portable projector is supplied by Houghton-Butcher, Ltd. A daylight screen is used.[186] At the photographic exposition, held this spring in Amsterdam, Holland, a projector was shown which accommodated both $9^1/_2$-mm. and 16-mm. films.[187]

Several additional pieces of equipment for home sound movies have been announced recently. The Talkiola is designed so that the film moves horizontally, in order to facilitate threading. The turntable and pick-up are housed in the same cabinet as the projector.[188] The Visivox is fitted with a special arrangement of a double-claw

movement, pilot pin, and loop adjuster, and operates without feed or take-up sprockets.[189]

The new 16-mm. Western Electric sound projector consists of a projector, a turntable, an amplifier, and a speaker, all of rigid construction designed primarily for classroom and sales or advertising use.[190] (Fig. 6.)

Patents issued relating to amateur projection equipment include

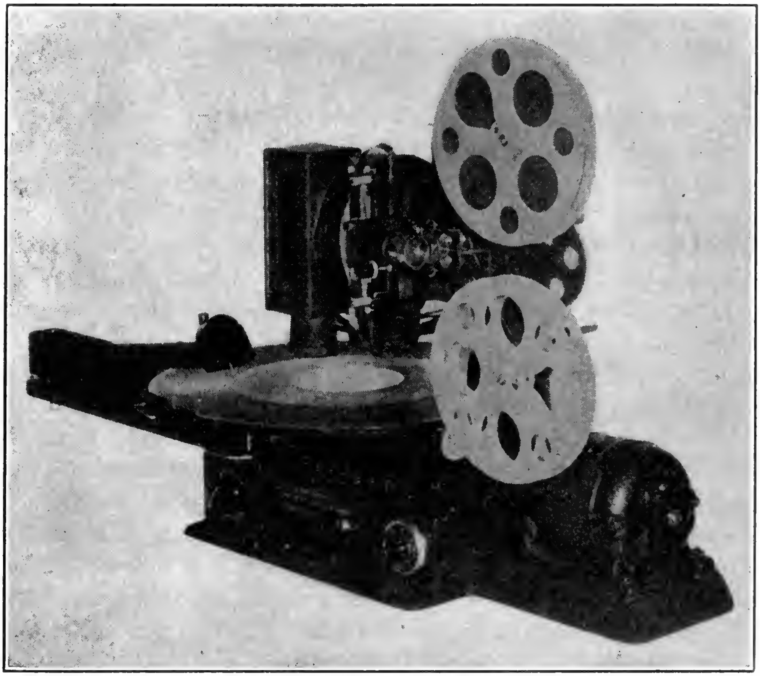

FIG. 6. Projector and sound reproducer for 16-mm. film. (Reproduced by courtesy Electrical Research Products, Inc., New York.)

several dealing with devices for synchronizing sound with the projected picture.[191]

Accessories.—The advanced cine amateur may now make his own wide pictures. A novel auxiliary lens system is available which consists of cylindrical lens elements giving a magnification of 1.5 in the horizontal plane only. The extra field is compressed into the width of a 16-mm. picture and magnified again on projection. About 15 per cent increase in exposure is necessary and the illumination on

projection is reduced about one third when the extra lens is used.[192]

A 15-mm. $f/2.7$ wide angle lens has been announced for the Model *K* Cine Kodak. It is interchangeable with the regular $f/1.9$ lens.[193] A new Cooke 4-inch projection lens has been marketed by Bell and Howell, which will give, at double the distance, the same size screen image as would be obtained with the normal lens at a shorter distance.[194]

A combined range finder and exposure meter has been marketed under the name, *Correctoscope.* It consists of a highly corrected lens, a reflecting prism, and a magnifying eyepiece. With certain types of cameras, the instrument can be geared to the camera lens, enabling objects moving toward or away from the camera to be kept in focus.[195] A focusing alignment gauge is a useful accessory for the Filmo, permitting greater accuracy in close-up shots.[196]

The introduction of larger diameter objective lenses for 16-mm. projectors has made possible the use of 110-volt tubular bulb concentrated filament lamps in which the monoplane light source has been made more compact than heretofore.

An illuminating unit for interior shots has been made available, which consists of an efficient reflector and a 500-watt bulb. It is used in combinations of one, two, or three light units.[197] A 400-foot projection reel having a (spot-welded) skeleton wire construction has been placed on the market.[198]

Five patents were noted dealing with amateur accessories.[199]

Films and Film Processing.—The high-speed "pan" films which the professional cameraman has had since the first of the year, have now been made available to the amateur. Holslag[200] states that one of these fast 16-mm. reversal films has twice the speed to daylight and three to four times the speed to artificial light as the older panchromatic emulsions. The former disproportionate sensitivity to the blue has been overcome so that color filters are less necessary, and a useful increase in yellow and red speed has been introduced. A German-made 16-mm. panchromatic reversal film of very high red sensitivity has also been announced.[201] Koenig[202] considered the logical solution of the sound-on-film problem for sub-standard film is to use sprocket holes along one side only and to place a 0.1 inch sound track on the other border. A more feasible solution is to increase the film width to 20 mm., and to place the sound track outside the perforation area. It is stated the 20-mm. film may be used on any pro-

jector now in use, and that 16-mm. film could be run on a 20-mm. projector.

A draft of a proposed German law regarding 16-mm. films was presented for consideration at the Eighth International Congress of Photography. This law is concerned chiefly with specifications for the determination of the inflammability and the combustibility of the film. The Congress suggested a slightly lower temperature of ignition and a shorter burning time than those proposed; also, that all samples be tested in the same width as supplied to the market.

A 16-mm. film developing, fixing, and washing rack of 100-foot capacity, made of monel metal, has been made available for amateur use. A winding rack and a developing tray are included.[203]

Two patents related to improvements in handling film were noted.[204]

Uses of Amateur Films.—Fardon[205] uses a double ocular to adapt his microscope for cinéphotomicrography, and a thermopile for determination of exposure. Rüst[206] has discussed the requisites of amateur cine apparatus for use in German schools. Günther[207] reported on several meetings held in Germany for the purpose of discussing problems in connection with educational films. In general it was agreed that 16 mm. is the most suitable width for this type of film, although some objections were offered.

B. Amateur Color Processes

As noted in the section under "Medical Films, Radiography, and Cinéphotomicrography," Stout has described the auxiliary lighting necessary for making surgical motion pictures in Kodacolor.

Examples of a lenticulated film process called Agfacolor were projected for the first time publicly before the session of the International Congress held in Dresden in August.

VII. STATISTICS

According to data published in a book by Jason entitled "Handbuch der Filmwirtschaft," there has been a 51 per cent increase in the number of European theaters since 1926. As of the end of the year 1930, there were 33,842 theaters compared with 22,425 in 1926. The seating capacity has increased 48 per cent, the present theaters seating about $1^1/_3$ million persons. There are now 72 theaters for each million inhabitants.

A report from the Motion Picture Division of the U. S. Department

of Commerce states that there are 1817 theaters wired for sound in Czechoslovakia and that about 50 million persons attend motion pictures yearly.[208] Another report from this same division states that 50 theaters throughout China have been equipped with sound apparatus, 35 of which are of American manufacture.[209] The number of theaters in Japan has increased 20 per cent in five years, and there are now 1488 theaters. Theater attendance is only fair, averaging about 150 persons at each performance. There have been 47 additional theaters in India wired for sound with American equipment in the last six months, making a total of 89 installations now in use. Seven companies are producing purely Indian "talkies," one in Calcutta and six in Bombay. The first all-native Indian sound picture has had a continuous run of 13 weeks in Bombay.

Differences in language cause quite wide variation in the length of a sound film. Five films made of the same picture by an American producer had the following lengths: English 8010 feet; Spanish and Italian 8259; French 8516; and German 9609 feet.[210]

Replacements of parts of sound equipment have been analyzed in an article published in *Electronics*. Tube replacements average $42 per month per theater or about 7 million dollars for the entire country.[211] An estimated total of more than three-quarters of a billion feet of film is printed annually by five of the largest American producing organizations.[212]

North and Golden[213] have published details on sound equipment sales abroad and estimate that 12,000 of the 37,000 theaters outside the United States had been equipped for sound pictures by the Spring of this year. Of the remainder only about 4000 represent a potential market. Interesting data on Latin-American conditions were given by these same authors at the 1931 Spring Meeting.[214]

Gross earnings for 1930 reported by 12 American companies (producers and manufacturers) were $421,927,400. Net income for 16 companies was $94,833,067.[215]

VIII. PUBLICATIONS AND NEW BOOKS

A new daily, *The Hollywood Herald*, was started during the past six months by the Quigley Publishing Company. It represents a companion trade issue to the *Motion Picture Daily* issued by this company from New York.

According to a report from a member of this Committee, formerly residing in Japan, there are 43 publications regularly appearing in

Japan devoted exclusively to the motion picture field. Of the total number 14 pertain to the trade, 7 to the studios, and 5 to exhibition, the remainder having miscellaneous applications.

New books which have appeared are as follows:

1. *Sound Film-Recording and Reproduction by the Klangfilm Process,* (*Tonfilm-Aufnahme und Wiedergabe nach dem Klangfilm-Verfahren*), by F. Fischer and H. Lichte, 455 pp., 378 figs., and illustrations, S. Hirzel, Leipsig.

2. *Sound Film Reproduction,* by G. F. Jones, Blackie & Sons, Ltd., London.

3. *Projecting Sound Pictures,* by A. Nadell, McGraw-Hill Book Co., New York.

4. *Handbook of the Film Industry* (*Handbuch der Filmwirtschaft*), Vol. II, by A. Jason, Wirtschaft and Politik, Berlin.

5. *1931 Film Daily Director's Annual and Production Guide,* Film Daily, New York.

6. *European Motion Picture Industry in 1930,* U. S. Government Printing Office, Washington.

7. *Publications from the Scientific Laboratory, Agfa, Photographic Division* (*Veröffentlichungen des wissenschaftlichen Zentral Laboratoriums, Afga Photographischen Abteilung*), Vol. II, by I. G. Farbenindustrie Aktiengesellschaft, S. Nirzel, Leipsig.

8. *The Photographic Camera and Its Accessories* (*Die photographische Kamera und ihr Zubehör*), by K. Pritschow, J. Springer, Vienna. This is Vol. II of *Handbuch der wissenschaftlichen und angewandten Photographie,* edited by A. Hay.

9. *Selenium Cell: Its Properties and Applications,* by G. P. Barnard, Constable & Co., Ltd., London.

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[192] *Amer. Cinemat.*, **12** (May, 1931), p. 36.
[193] *Movie Makers*, **6** (June, 1931), p. 334.
[194] *Movie Makers*, **6** (Aug., 1931), p. 442.
[195] *Movie Makers*, **6** (May, 1931), p. 287.
[196] *Amer. Cinemat.*, **12** (May, 1931), p. 41.
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[199] U. S. Pats. 1,795,442, 1,799,748, 1,804,730, 1,805,185; Fr. Pat. 685,003.
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[201] *Brit. J. Phot.*, **78** (Sept. 11, 1931), p. 550.
[202] *Electronics*, **2** (May, 1931), p. 621.
[203] *Movie Makers*, **6** (Sept., 1931), p. 492.
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[206] *Kinotechnik*, **13** (Aug. 20, 1931), p. 297.
[207] *Kinotechnik*, **13** (Aug. 20, 1931), p. 299.
[208] Reports Mot. Pict. Div. U. S. Dept. Com., July 8, 1931.
[209] Reports Mot. Pict. Div. U. S. Dept. Com., May 13, 1931.
[210] *Kinemat. Weekly*, **171** (May 21, 1931), p. 57.
[211] *Electronics*, **2** (June, 1931), p. 686.
[212] *Mot. Pict. Herald*, **103** (June 20, 1931), p. 13.
[213] *Electronics*, **3** (July, 1931), p. 11.
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APPENDIX

MOTION PICTURES IN NORTH CHINA*

Perhaps in no other country is the theater more popular and better patronized than in China. The basic reasons for this popularity are: (1) the Chinese stage is largely devoted to the portrayal of historical, legendary, and other scenes and themes dear to the heart of a homeloving, though highly illiterate, people who have an almost boundless respect and admiration for the past; (2) the theater

* This material has been edited from Bull. No. T-48 of the Motion Picture Division, U. S. Dept. of Commerce, issued May 20, 1931. It was prepared for the Division by U. S. Consul A. I. Ward, Tientsin, China.

is the one avenue through which the struggling masses may escape, even though only temporarily, from the cares of an almost barren existence. This Chinese taste for the theater extends to motion pictures.

Motion Picture Theaters in North China.—One of the first, if not the first, motion picture theater in China, the Peking Pavilion, was established in Peiping (then Peking), in 1901. The first motion picture theater at Tientsin, the Arcade (later known as the Empire), opened during 1905. The motion picture theater industry in North China passed through practically the same experiences as elsewhere, the principal exception being that its development was not accompanied by any marked expansion in the rural districts or in the cities other than Tienstsin and Peiping. Each of these cities have a population of approximately one million. There is an estimated population of about 58 to 68 millions in the consular district of a million and a half square miles.

During 1929 the first exhibitions of sound pictures were given at Tientsin and Peiping, but not until the winter of 1929–1930 did any local theater begin to give regular presentations of sound pictures. There are at present four theaters at Tientsin (the Chung Tien, the Hsin Hsin, the Olympic, and the Palace) and two at Peiping (the Central and the Chen Kwang), all of which exhibit silent pictures at present, but are about to install sound equipment. The motion picture theaters (both silent and sound) at Tientsin and Peiping are, with few exceptions, devoted exclusively to screen showings. The few exceptions, five in number, present Chinese drama and opera as well as motion pictures.

Other than a club at Tangshan and one at Chinwangtao, in Hopei Province (both of which are operated for the foreign employees of the Kailan Mining Administration and which exhibit silent motion pictures once a week), and a theater exhibiting silent motion pictures in Taiyuan (Shansi Province), there are no regular motion picture houses outside the cities of Tientsin and Peiping. At times, the theaters in the largest of the lesser cities, such as Shihchiachwang, Paoting, Shunteh, and Taming, exhibit motion pictures as a special attraction.

The motion picture theaters at Tientsin and Peiping are classified as "first run," "second run," and "third run." Admission prices in the first run theaters range from Yuan \$0.50 to \$2.00 (U. S., \$0.11 to \$0.44), in the second run theaters from Yuan \$0.20 to \$0.80 (U. S., \$0.04$^1/_2$ to \$0.17$^1/_2$), and in the third run from Yuan \$0.10 to \$0.30 (U. S., \$0.02$^1/_4$ to \$0.06$^1/_2$). Notwithstanding the lower admission price, a film frequently earns more in a second run theater than in a first.

Preferred Types of Pictures.—While sound pictures are more popular than silent pictures, the percentage of showings of the latter is higher, principally because of the lower admission prices. Of the American films exhibited at Tientsin and Peiping during 1930, it is estimated that 80 per cent were of the sound type. No Chinese sound pictures (that is, film recording) have been shown in North China, but one such picture is expected to be presented very soon. Several Chinese silent pictures have been successfully shown at Tientsin and Peiping with dialog and music reproduced from disks. In studying the types of pictures preferred locally, it should be noted that the tastes of the foreign populations and of the Chinese are distinct, and must be considered separately.

Local distributors state that the tastes of the Tientsin motion picture public

differ widely from those of the Peiping public. The non-Russian foreigners at Tientsin seem to prefer pictures with light plots, preferably musical shows and comedy themes. The Russians at Tientsin and the foreigners at Peiping prefer dramas or pictures with well-reasoned plots.

As previously mentioned, the Chinese stage is devoted to the portrayal of historical, legendary, and other like themes. Professional story-tellers may be found today in almost any market place or amusement park. But, as so few Chinese in this part of China have traveled abroad or have come into close contact with the American and European manner of living, it is evident that the subject matter of, and scenes in, many of the American and European films are entirely incomprehensible to the great majority of the Chinese. Owing to this lack of understanding of foreign life, the types of foreign motion picture generally preferred by the Chinese throughout this part of China are comedy and action, such as adventure, war, and "Western" pictures. Chinese motion pictures have a greater grip on the Chinese than have foreign productions since their plots, themes, and settings are more readily understood by all.

The widespread ignorance of the English language probably accounts for the small percentage of Chinese patrons at theaters showing sound pictures. The Western European residents in China, as well as the educated Chinese, are usually able to speak and read English, and therefore can enjoy silent motion pictures with titles and subtitles in the English language. For those who do not understand English, titles and subtitles in Chinese and Russian are projected with the aid of a stereoptican lamp upon a supplemental screen placed alongside the picture screen. No Chinese sound pictures have yet been exhibited at Tientsin.

There are no film studios in the Tientsin consular district, but it has been learned that the United Photoplay Service (Ltd.), a Chinese enterprise with head offices in Hong Kong, contemplates the erection of a studio at Peiping, for the production of Chinese sound and silent pictures.

DISCUSSION

MR. KELLOGG: In the course of the year—last Spring, I believe—a paper was read which dealt with the magnetic type of microphone, which has directive properties which the condenser microphone did not have. This ribbon microphone, as it has been called, is practically insensitive to sound waves coming from the side, and I am told that that has made a very notable improvement in the ease of getting proper acoustic effects in recording. I notice in the report that another type of magnetic microphone was shown. I do not know the properties of the other microphone, but I believe the most important characteristic of the ribbon microphone, described in the paper by Mr. Olson, was the directive property mentioned by him.

MR. MATTHEWS: It seems pertinent at this point to remark that it is extremely difficult to get people to contribute information to the Committee. I manage to get reports from the Committee members themselves, but to get anything from others is an achievement. I should like to make an earnest plea, for whoever is Chairman of the Committee for next year, that if any one knows of work of outstanding interest in his particular field, he forward a brief summary of the essential features of it to the Chairman of the Committee. I believe, if I remem-

ber correctly, that the details of the paper by Mr. Olson are mentioned in the report of the progress Committee for May, 1931. (*J. Soc. Mot. Pic. Eng.*, **17** (July, 1931), p. 79).

MR. HUSE: There is one subject which Mr. Matthews did not mention, which may be covered in the detailed report, which deals with the electrolytic recovery of silver from fixing baths. As is generally known, Metro-Goldwyn-Mayer processes approximately two million feet of film per week, and their silver is electrolytically recovered by the process and equipment designed by Mr. Hickman. If that is not mentioned, it should be contained in the report.

PRESIDENT CRABTREE: You will find a full description of this process in the October issue of the JOURNAL.

MR. MONOSSON: As far as I know, in the past six months, there has been a tremendous improvement in sound production and development of sound apparatus in Russia. In 1930 there were only four sound pictures produced in the U. S. S. R. All recording and producing in the U. S. S. R. is done by a method due to two Russian Engineers, Professor Shorin and Professor Tager. Only four pictures were produced in 1930, but thirty pictures in 1931. The program for 1932, as announced by the Chairman of the Motion Picture Syndicate in the U. S. S. R., provides for eighty sound pictures, including among them twenty color pictures, all based on a process developed in the U. S. S. R.

In 1932 there will also be an increase in the production of feature pictures. In 1931 about two hundred and thirty-one pictures were produced, and for 1932 the program provides for five hundred full-length features.

The most important thing in the development of the motion picture industry in the U. S. S. R. is the establishment of three new plants for producing film raw stock. Russia did not produce any film raw stock until 1931. The program for 1932 provides for the production of one hundred sixty-five to two hundred thirty-five million feet of raw stock film, in three new plants, one in the Ukraine, and two on the Volga. Besides, the program provides for the construction of a plant for producing four hundred and ninety million feet of raw stock a year. This plant will be established this year, and will be in operation early in 1932.

There are three new studios in the Far East, in Central Asia, Siberia, and in White Russia, to be constructed. There will also be installed in 1932, some fifty-five hundred sound reproducing units, about twenty thousand machines for projecting sixteen-millimeter film, and between ten and eleven thousand sound projection machines.

This means that in 1932 the program which is worked out will be tremendously increased, in connection with the necessity of giving more entertainment and more education to the masses in the U. S. S. R.

A METHOD FOR QUANTITY DEVELOPING OF MOTION PICTURE FILMS*

C. ROY HUNTER AND ROBERT M. PIERCE**

Summary.—*This paper describes an improved machine for developing motion picture negative films in use at the laboratories of the Universal Pictures Corp. A thorough description of the machine and its operation is given. The system involves the so-called reversal process.*

In 1928 a paper[1] was presented dealing with a machine for developing motion picture negative films, which had been at that time in daily use over a period of six months at the laboratories of the Universal Picture Company.

During the three years that have elapsed from that date, nearly all the Hollywood laboratories and many of the Eastern laboratories have been equipped with negative developing machines, which have proved successful with regard to both the technical and the commercial aspects of laboratory procedure.

Three years of experience, during which several million feet of negative film have been developed in machines, have dictated alterations in their design and construction which have been carried on according to the findings and the ideas of the experts and researchers affiliated with the various laboratories.

It is not the purpose of this paper to present a survey of all negative developing machines that are to be found in Hollywood, but rather to lead to the main subject of this paper through a brief description of the Hunter-Pierce machine now in use at the Universal laboratories.

Fig. 1, at 2, shows a general view. The first striking difference noticed in this type of machine, comparing it with the old one, is that the film is carried in horizontal troughs instead of in vertical tanks, and that the drying cabinet tops the machine throughout its length.

* Presented in the Symposium on Laboratory Practices at the Spring, 1931, Meeting at Hollywood, Calif.

** Universal Pictures Corp., Universal City, Calif.

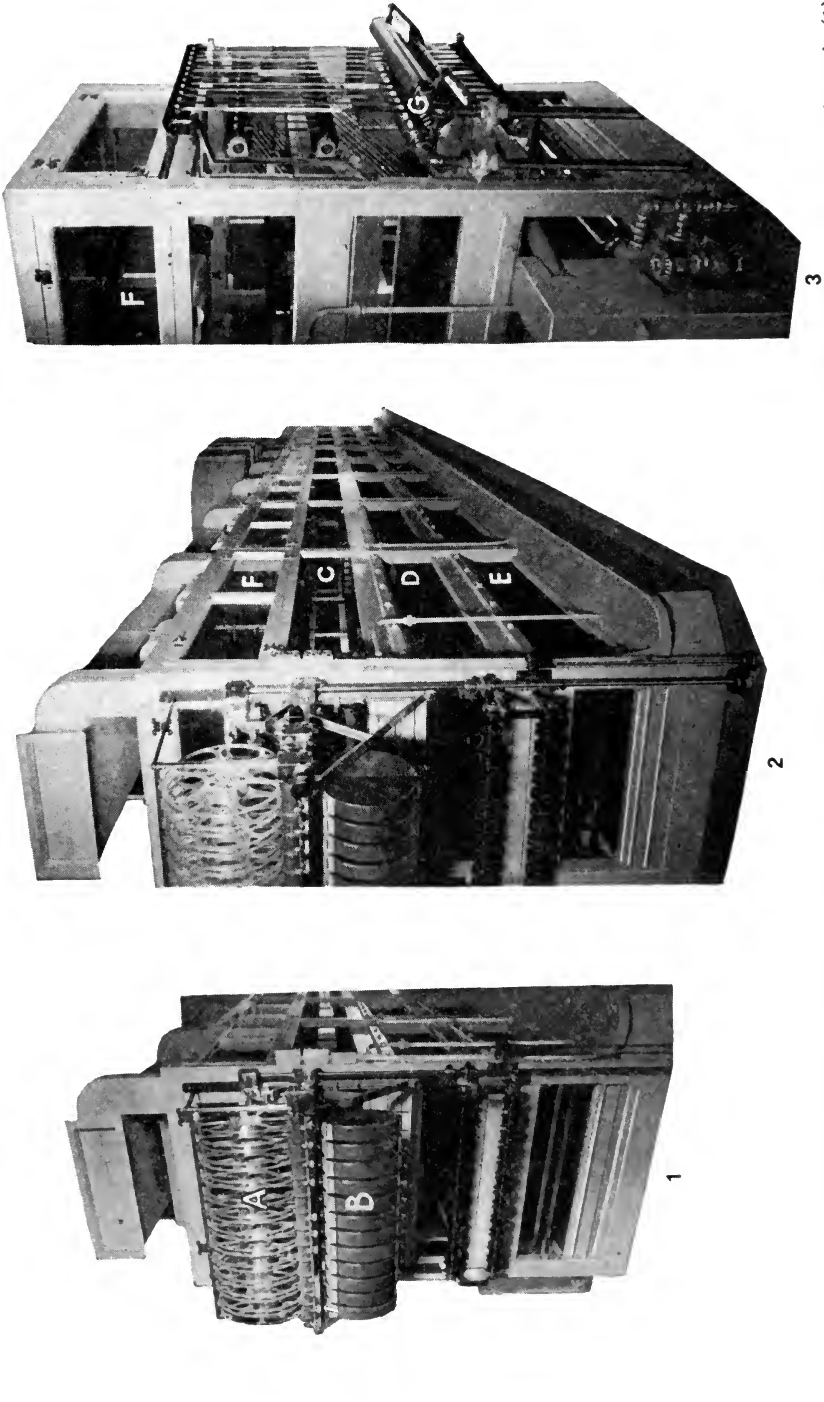

FIG. 1. (1) The loading end of the developing machine; (2) a general view of the machine; (3) view of the end opposite that shown in (1).

At 1 (Fig. 1) is shown the loading end of the machine. The unexposed film is enclosed in the magazines at *B*, and after the completion of the processing, it rewinds on the take-up reels *A*. There are twelve magazine units and twelve take-up reels, the rotative motions of which are independently controlled so that twelve or any lesser number of film strands can be processed at the same time, independently of each other except for the time necessary to complete the cycle of operations, which is constant for all strands.

It may be remarked here that the speed of the machine is variable and can be controlled at will within reasonable limits; and furthermore the time of development can be varied within very close limits by displacing a set of rollers which determine the point at which the film first comes into contact with the developing solution.

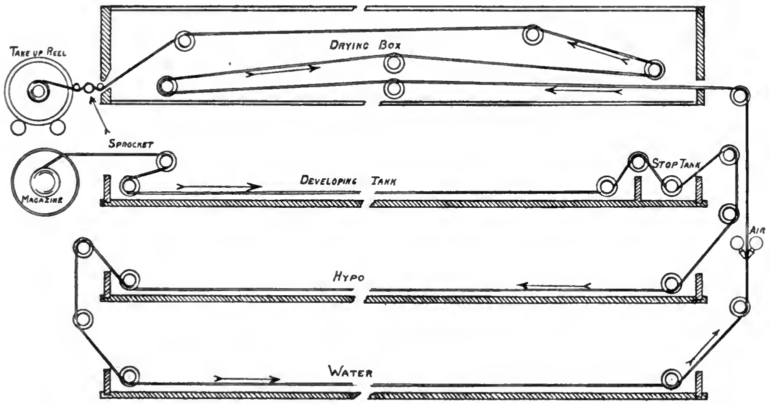

FIG. 2. Schematic elevation of machine, showing path followed by film.

The loading magazines swivel on a common axis, and are counterbalanced so that when fully loaded the weight of the film holds them in a downward position, whence they automatically rise according to the amount of film fed into the machine. The operator is therefore constantly informed of the amount of film left in each magazine, and is constantly prepared to reload without loss of time and without the danger of having a loose end of film enter the developer's trough.

Upon leaving the magazine, the film is led under a series of rollers (one for each strand), which hold it submerged in the developer trough (*C*). At the end of this trough is a small compartment in

which the film is sent through a quick-stop bath and is guided (Fig. 1, at 2) by rollers into the fixing trough *D*.

The film runs now in a direction opposite to that followed in the course of development, and, thoroughly fixed, leaves the trough at the load-end of the machine (Fig. 1, at 3) where it is led into the washing compartment, *E*, which is the lowest compartment of all. Before entering and after leaving the washing trough, the film is made to pass between a pair of water sprays which rinse the film on both its emulsion and base surfaces.

After being washed the film leaves again at the opposite end of the machine (Fig. 1, at 3), and is brought up to the drying compartment, *F*, and made to pass between a series of compressed air blowers, *G*, which remove the excess moisture from both its emulsion and base surfaces.

Fig. 2 schematically shows the path followed by the film through the machine. It will be noted that the drying cabinet is of sufficient height and that the sets of rollers are so disposed as to allow the film to run back and forth in it three times before being led to the take-up reels.

The film is driven by a single sprocket located at the take-up end of the machine. The use of a single sprocket and the perfect setting of all rollers automatically compensate for the natural swelling of the film so that it is fed into all compartments with a constant and steady motion.

Needless to say, the developing and fixing solutions are kept in constant circulation and are automatically replenished. Their temperature is maintained with 0.5° of a predetermined standard value. Three tests are made every half hour—a gamma test, a transmission test (which is taken by reading any two predetermined squares of the densitometric strip within the straight portion of the characteristic curve), and a visual test consisting of visually examining a strip of film exposed under standardized conditions with regard to intensity and spectral quality of light. These tests determine the proper amounts of "booster" or "sweetener" which constantly drip into the circulating vats. The humidity of the air in the drying cabinet is measured with the dry and a wet bulb hygrometer. The film is accessible at all times at any part of the machine and can easily be reached by hand at any point *en route* for viewing or for any purpose whatsoever.

The following dimensions and data will serve to complete the summary information contained in the above description:

Length of the machine, over all	$51^1/_2$ feet
Length of developing trough	46 "
Length of "short stop" trough	2 "
Length of fixing trough	48 "
Length of drying cabinet	48 "
Capacity, per minute	120 "
Developing time (approx.)	5 minutes
Capacity of loading magazines	1400 feet
Developer circulation, per minute	25 gallons
Fixing bath circulation, per minute	12 "
Water circulating per minute	12 "

The success which has been met in operating the improved developing machine, the constancy of the results obtained through the accurate control of its running speed that it permits, and of the strength and temperature of the solutions, have encouraged the authors to investigate a method of printing film in large quantities which will provide improved quality in addition to a reduction in operating costs.

Although the method here suggested has not yet been put into actual use, the results of experiments conducted over a period of more than a year have been so conclusive that the authors feel that a general description of the method would be quite in order at this time. Much data have been collected in the course of research and experimentation but the labor of condensing it into a comprehensive form is so great that it is not possible at this time to present it in a proper academic form.

It is well known that 16-millimeter films for amateur use are treated in the finishing stations by the so-called "reversal process"; and it is also well known that this process has been brought to a high degree of perfection, the quality of the "reversal" films being comparable with that of the best "release" prints made by and for professionals. These remarkable results have suggested to the authors the possibility of adapting this process to the printing of professional films. We may at first analyze the advantages of the method.

After a picture is edited and assembled, one or more master prints of utmost perfection can be made, which can be used in any of the printing machines to be found on the market for duplicating them into prints for release purposes. The two main considerations in favor of this method are (*a*) protection of the negative, and (*b*) saving of time.

It is well known that a negative cannot be printed more than 250

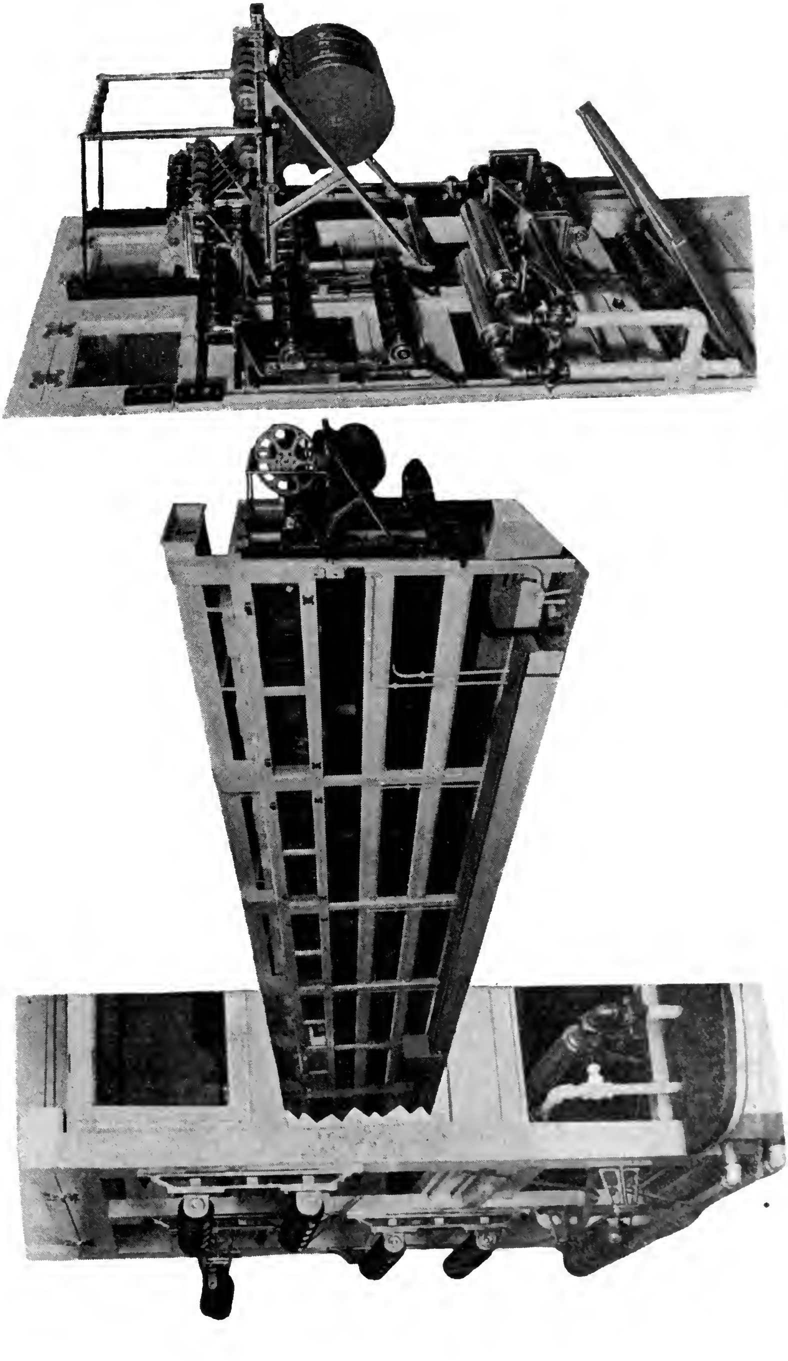

FIG. 3. General appearance of the modified negative developing machine adapted to the "reversal" process.

times and that after 100 prints are made the film deteriorates rapidly, impairing the quality of the prints.

The method suggested here lengthens to an indefinite extent the life of the negative as regards the quality of the image, wear and tear, shipping risks, and fire hazards. A considerable saving of time and labor can be effected, especially when release prints have to be quickly delivered to the exchanges for public distribution, where it will be possible to prepare several master prints to be used simultaneously in as many printing machines.

With regard to foreign releases, the reversal method of printing releases will permit shipping the required number of master prints to the various countries in place of the "dupe" negatives or the

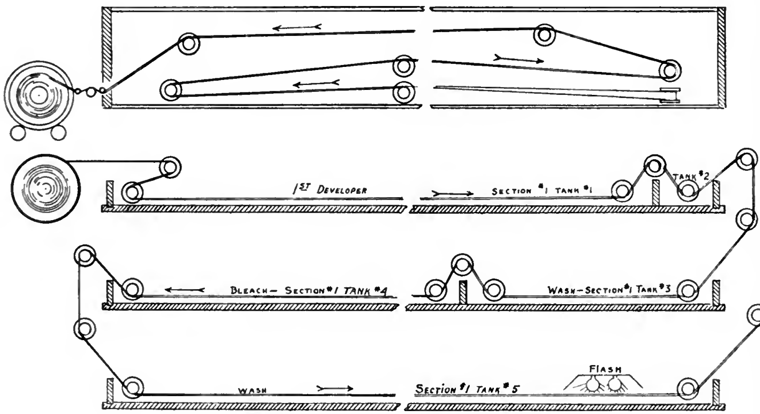

FIG. 4. Schematic elevation of section 1.

spent original as is the case today. This will obviously insure that foreign releases will be of the same quality as the domestic.

With regard to quality, the experiments conducted by the authors have conclusively proved that the "reversal method" will not affect the high standard of quality now exacted of all processing laboratories, and it will ultimately result in improvement rather than in loss, especially with regard to the following considerations.

Since the release prints are produced from a "master positive," the latter can be prepared with the greatest care, regardless of the cost and the time involved, which are amply compensated for by the rapidity and automatic accuracy with which the ultimate release prints are made.

Once the master print is made and assembled so as to represent the degree of perfection obtainable from the negative and demanded by the cinematographer and the director, release printing becomes an automatic procedure because of the elimination of the human element involved in the usual method; it is only necessary to take care that

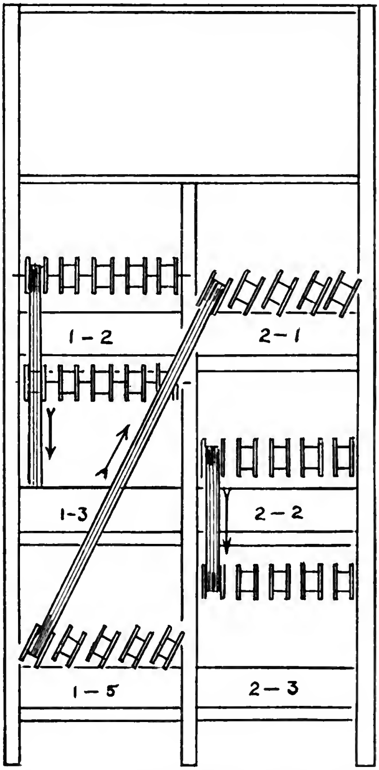

FIG. 5. End view, showing cross over from section 1, tank 5 to section 2, tank 1.

the positive stock, the printing light and the speed, and the developer should correspond to the standards decided upon when making the master print.

The reversal of the image has been obtained by the authors by adopting the well-known "flashing" method, which involves the following series of operations:

(1) The exposed film is developed.
(2) It is immersed in a "short stop" bath to check development.
(3) It is rinsed in water.
(4) It is bleached to eliminate the silver deposit forming the negative image.
(5) It is thoroughly washed.
(6) It is "flashed" or fully exposed to a light of predetermined intensity and spectral characteristics.
(7) It is fully developed as a positive.
(8) It is washed and cleaned, and finally,
(9) It is dried.

It is obvious that these operations must be carefully controlled with regard to the time of processing, the composition and constancy of the processing solutions, and their temperatures. This control is

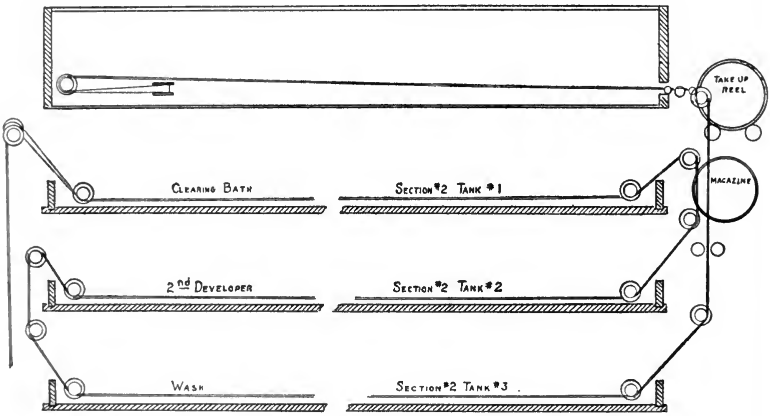

FIG. 6. Schematic elevation of section 2.

automatically obtained by modifying the Hunter-Pierce negative developing machine and by adapting it to the "reversal" process as illustrated and described as follows.

Fig. 3 shows that the general appearance of the machine is unaltered except for the fact that only five loading and take-up magazines (and consequently only five strands of film) are used instead of twelve. This is the result of dividing the machine longitudinally into two main sections to permit bringing the film through a second developing trough after the "flashing" operation.

Fig. 4 is a schematic drawing which shows the path of the film as it leaves the magazines. From the magazine the film is brought into a developing trough (section 1, tank 1), whence it passes into a short

stop bath (tank 2). Leaving at the rear end of the machine, it enters a wash tank (section 1, tank 3), and is then immersed in the bleaching solution (section 1, tank 4). It is then washed (section 1, tank 5), and flashed by neon lights, and at the end of the washing trough the film is immersed in water.

Fig. 5 shows the film leaving section 1, tank 5, and entering section

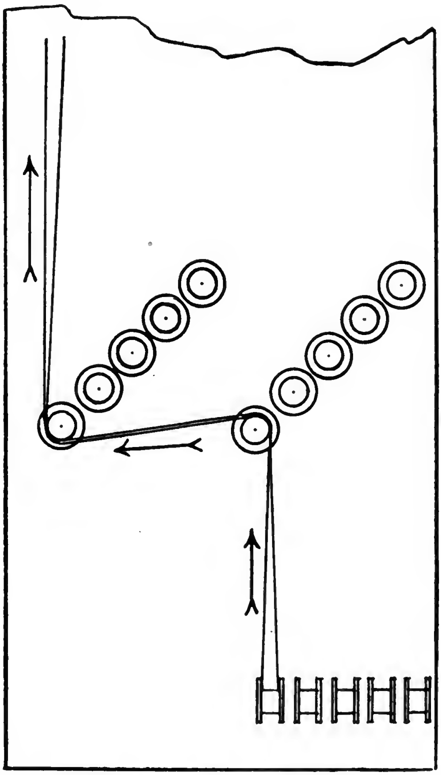

FIG. 7. Floor of dry box, showing cross back from section 2 to section 1.

2, tank 1, which is a cleaning bath trough adjacent to the quick stop tank, No. 2, and the first developing trough, tank No. 1. (Fig. 6.) The film then moves downward at the loading end of the machine into the second developing trough, which runs the whole length of the machine along the side of the bleach and wash tanks, No. 4 and No. 5.

After being developed, the film is washed in the lowest compart-

ment of the machine (section 2, tank 3); it leaves at the loading end and is led into the drying compartment after passing through a series of pairs of air blowers. Fig. 6 shows how the film is made to cross over from section 2 to section 1, the whole width of the drying cabinet being used for this purpose. The more complex path of the film has not increased the difficulties encountered in maintaining constant and smooth motion under extremely low tension.

In the course of experimentation the authors have, quite naturally, given a great deal of attention to the graininess of the prints obtained by the reversal process. It is not possible to describe in detail the processing methods which are still in the course of investigation; these will be made the subject of a paper to be presented at a later

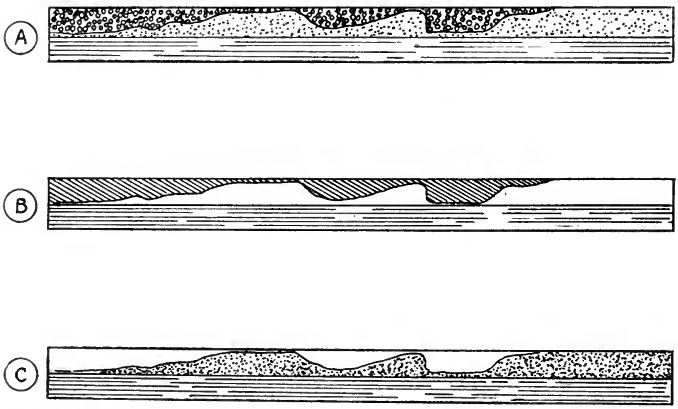

FIG. 8. Schematic cross section of a film, showing grain structure.

date. It is possible, however, to state that these experiments have conclusively proved that the suggested process produces prints in which the graininess is much less visible than in prints obtained by the regular process.

Fig. 7 indicates the results obtained. Diagram *A* illustrates the effect produced on printing a negative directly on a strip of positive film. The graininess of the negative stock is "added" to that of the positive, and the obvious result is that the finished print shows the graininess of both, which may be expressed as the cumulative graininess of the several layers which may be considered as forming the thickness of the emulsion.

It is known that one of the greatest difficulties encountered in a

reversal process is due to the use of developing solutions rich in alkali, which cause deterioration of the gelatin. The authors are not quite prepared to disclose at this time the means used for eliminating this serious factor. It will be discussed later, when the method will have proved to be a commercial success. It may be mentioned, however, that there is brought about a general partial reduction of the silver halide into metallic silver in the undeveloped portions of the film.

In diagram *B* is shown the effect produced by bleaching the negative image, which results in eliminating the negative grain in addition to reducing the grain layer illustrated in diagram *C*. It must also be borne in mind that the larger and more sensitive grains of the emulsion, on account of their off-printing for the light transmitted in the first exposure, have been completely reduced by the process of development, and consequently are destroyed by the bleaching as shown at *B*.

The sensitive material which remains in the emulsion after bleaching, if fully exposed to a neon light rich in short wave radiations, is reduced to metallic silver through the regular developing process. The resulting positive image has obviously the small grain characteristic of the low speed emulsion such as used in the process. In Fig. 8, at *A*, is shown a print made directly from a negative, and at *B* a print obtained through the "reversal process" from a master print obtained from the same negative.

At the present time two of the "reversal process" machines are being installed in the Universal laboratory, and are expected to be fully operating before the next convention of this Society. At that time the authors intend to present further information on the process and to project films developed by this process.

REFERENCE

[1] HUNTER, C. ROY: "A Negative Developing Machine," *Trans. Soc. Mot. Pict. Eng.* (1928), No. 33, p. 195.

NOISE MEASUREMENT*

S. K. WOLF AND G. T. STANTON**

Summary.—*The instrumental measurement of noise presents difficulties that have in the past generally defeated its successful accomplishment. While noise exists in a physical state and certain of its quantities are susceptible to direct measurement, the magnitude of a noise is evaluated through the interpretation of the human ear. The ear is non-linear in its evaluation of the various factors of noise. The degree and nature of the ear's non-linearity to the principal factors is discussed, with respect to the chief interpretative impression, that of loudness.*

Audiometric measurements approached a more proper evaluation of noise, but in addition to dependency upon human judgment, were only approximate, and represented comparisons of physiological effects of noise rather than true noise values.

An instrument is described that measures intensity expressed in terms of loudness, evaluated for frequency and duration, and which combines portions of a complex wave-shape in a suitable manner. The characteristics of the meter and the ear are compared. The readings are in decibels above a zero reference point near the threshold of audibility. The selection and meaning of this scale is explained. Where it is desired to analyze the pitch or frequency of a noise, an analyzer attachment permits either band or single-frequency analysis. Some limitations in its use in making noise measurements are discussed.

The instrumental measurement of noise presents certain difficulties that have in the past generally defeated its successful accomplishment. The basic reason lies in the fact that noise is of itself an extremely complex physical manifestation, and further, that it is evaluated through the agency of the human ear. Instrumental means of measurement were available by which many of the different physical factors could be measured. However, unless these physical factors are evaluated in the same manner as they are recognized by the ear, erroneous conceptions of the magnitude of the noise may be gained. The ear and its associated mechanism by means of which a mental impression of noise is conveyed to the brain, does not evaluate the physical characteristics of noise in a direct linear manner, but rather introduces a complex distortion. The nature of the ear's charac-

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Electrical Research Products, Inc., New York, N. Y.

teristics, and considerable quantitative data on this subject, are available in literature.

The principal physical characteristics of noise which affect the interpretation by the ear are the intensity of the sound, the frequency, duration, and the wave-shape. The action of the ear in evaluating these factors is complex and is to some degree dependent for its interpretation of one factor upon the value of one or more of the others. Before considering the effect of each individual factor, it must be determined which of the mental impressions caused by noise is to be used as a basis for measurement. It appears obvious that loudness is by far the principal impression received, and is the one of greatest importance. In addition, we have an appreciation of pitch, and, to some degree, we sense duration. Some consciousness of complexity of wave-shape may be present. In the case of musical instruments, we interpret wave-shape as "timbre." Loudness may, therefore, best be considered as the characteristic to be measured. We may then determine the manner in which the ear evaluates the various physical characteristics with respect to this factor.

The intensity of sound in acoustic determinations is the power of a sound wave passing through a unit area. True to basic physiological laws, the ear appreciates the relative loudness of two sounds of the same frequency approximately in proportion to the logarithm of the ratio of their intensities, at least through the middle of the audible intensity range. Consequently, in comparing the intensities of sounds from the standpoint of loudness, it is convenient to employ a unit representing the logarithm of the intensity. By so doing, the difference in value of the expressed units gives a measure of the ratios of the intensities, or approximate relative loudness. It should be noted that relatively great increases in loudness may be obtained from very small increments in pressure at points in the loudness scale near the minimum threshold of hearing, whereas large power changes are required to secure an equivalent increase in loudness for a very loud sound. The decibel, which is a logarithmic unit, is convenient for expressing this factor. Thus a range of one hundred decibels represents an intensity range of ten billion to one.

The pitch of a pure tone is determined by its frequency, generally expressed as the number of cycles per second in a pressure wave. Different frequencies of the same physical intensity are not generally appreciated by the ear as having the same loudness. The relationship between the loudness of sounds of different frequencies but of the

same intensity is complex and, in general varies with intensity. Intensities required for sounds of low frequency to produce a given loudness are larger than those for sounds of higher frequency. The ear also is not so sensitive to sounds of very high frequency; above four of five thousand cycles additional energy is required to give impressions of equal loudness. The ear may, therefore, be said to apply different weighting values to sounds of different frequency. These values have been experimentally determined for a wide range of different intensities.

The ear may be considered to have ballistic characteristics; that is, a sound of very short duration is not fully appreciated in terms of loudness. As the duration of the sound is increased its loudness is judged by the ear as progressively greater up to about 0.2 second. It is therefore of importance in measuring noise that the duration of each individual impulse be evaluated in a manner similar to that of the ear; otherwise, there may be a wide discrepancy between the values given by the measurements and the apparent loudness as observed. This is particularly true with sharp, intermittent noises.

One form of noise measurement that has found considerable application is the so-called audiometric method, which employs an observer and a standard source of sound. The measurements made are of two general types, comparison and masking. In the comparison type, the observer listens to a standard tone, generally produced through a telephone receiver, and varies the intensity of the standard tone until the tone and the noise appear of equal loudness. Unless the comparison tone and the noise are of much the same quality, a loudness balance is difficult and there is considerable variation in the judgment of different observers. Measurements made in this manner are complicated where the noise is of an intermittent character. The method is therefore more suitable for research, where the average obtained from a large number of observers may be desired. In the so-called masking type of audiometric measurements, an observer must calibrate his hearing in an absolutely quiet room and determine the minimum intensity of the standard source which he can just hear. The noise enters a specially designed telephone receiver and is mixed with the standard tone. In measuring the values of the noise, the observer adjusts the intensity of the standard tone so it can just be heard in the presence of the noise. The increased intensity required in the presence of noise compared with that required in a quiet place represents the masking value of the noise. This is of special interest where the effect on hear-

ing speech is concerned, as it evaluates the loss of intelligibility due to the noise. It is, however, of only partial value in determining the actual magnitude of the noise, since the ability of a noise to mask a sound depends to a large extent upon the composition of the noise. Different frequencies exhibit different masking effects and, moreover, the masking value for a given frequency varies in a non-linear manner

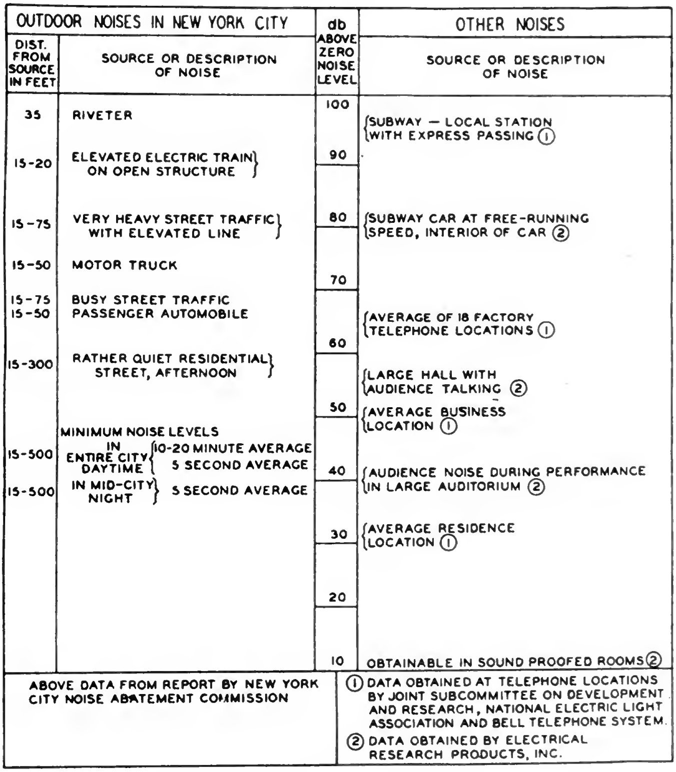

FIG. 1. Levels of noises, in decibels.

with the intensity. Noises of an intermittent character introduce further difficulties. Masking audiometers, employing pure tones of different frequencies, and employing bands of "warbling" frequencies, are sometimes employed with a view to determining the relative masking of noises for sounds of different pitch or frequency. Such measurements do not furnish a true evaluation of the relative loudness or of the energy in the frequency bands, but again refer only to the

masking values of the noise, which are only partially indicative of their loudness.

As expressed before, an instrument for the measurement of noise must evaluate its components in the same manner as the human mechanism of hearing. Thus, a meter which measures intensity and expresses this in terms of loudnesss, evaluated for frequency composition of the sound and for duration of the sound, will express numerical values proportional to the loudness sensation. As the interpretation of intensity is primarily logarithmic, the decibel may be selected as the unit for expressing the values. Mathematically, the intensity level in decibels is calculated by means of the formula $10 \log_{10} (I/I_0)$. Here I and I_0 represent the intensities of two sounds which are to be compared. This is logical, since the judgment of loudness is always based upon a comparison of the relative loudness of two or more sounds. In order to construct a scale of loudness, we must then have one fixed point to which all other sounds may be compared. If, in an absolutely quiet room we produce a sound so feeble that it cannot be heard, and gradually increase its intensity, a point is reached where it just becomes audible. This is termed the *threshold of audibility* for this sound, which is generally selected as the zero point for a scale of relative loudness. The average intensity required to produce such a sound of zero loudness has been determined. If, therefore, we place this value for I_0 in the above formula, by substituting the intensity of any such sound for the value I, it is placed in the scale relative to the minimum audible value. Fig. 1 indicates a decibel scale for various sounds which are familiar. Thus, a measurement evaluated on this scale may be located comparatively to other sounds or noise to which we may be accustomed.

In considering the design of a sound meter, it is obvious that it should meet, as nearly as practicable, the physiological requirements outlined above, in addition to which certain physical requirements are added. To meet the physiological requirements the meter should, as before stated, indicate loudness for a given intensity, giving due weight to the frequency or frequencies involved, and to the duration of the sound. The meter must also meet certain physical requirements, such as freedom from overload, electrical shielding, and must be susceptible to proper calibration, as well as to be reasonably portable.

A meter has recently been designed which simulates the action of the ear with regard to the physiological requirements. The meter

and the attentuators are so designed that the reading of the meter is directly in decibels above a fixed reference point. Absolute calibration of the meter is made by comparing the meter measurements with those of a Rayleigh disk. The fixed reference pressure is of a value near the threshold of audibility for the average ear. The meter can measure sound levels ranging from about 10 to 100 decibels above this reference point. Sound levels outside this range are seldom encountered. The major steps of level are determined from the position of the calibrating gain control, the additional value appearing on a logarithmically indicating meter extending over a long scale, covering a range of about 14 decibels. This permits reading the average value of varying noise on the lower part of the meter scale, and observing the magnitude of the peaks by a swing of the needle across the scale. In practice, the level of a sound is obtained by adding the meter reading to that of the gain control.

As previously pointed out, loudness varies for tones of different frequency and also with respect to the intensity. To represent exactly the frequency weighting of the ear would require a continuous change in the weighting network for each change in intensity. As this is not feasible in a portable instrument and would be of doubtful value, a weighting characteristic for tones of about 40 db. loudness has been selected. For sounds of very low frequency or of levels greatly differing from 40 decibels, a slight discrepancy may be introduced. However, the magnitude of the error is small and will not disturb the relative value of noise readings. The frequency weighting network is designed to cover the range of frequencies normally encountered.

Since the loudness of a tone of short duration is dependent upon the length of time it persists, the chief consideration in the design of the dynamic characteristics of the output circuit is that the meter reading shall reach its full value for sounds of two-tenths of a second duration. This corresponds very closely to the experimental data on the similar characteristic of the ear. The output meter needle does not move too rapidly to be read by the eye, but is sufficiently well damped so that it does not overshoot its maximum deflection by more than one-half decibel. The fact that the meter responds to sounds of short duration approximately in the manner of the ear, can readily be demonstrated by watching the movement of the needle and simultaneously listening to the variation of the noise being measured. The importance of proper dynamic characteristics is illustrated in the

following table, in which a meter having the above characteristics was compared with one requiring about five seconds to reach approximately full-scale value. The slow-acting meter gave maximum readings far below those of the more rapid meter.

Type of Noise	Approximate Difference in Readings
Short blast from automobile horn	25 db.
Sharp blow on large metal can	30 db.
Single, short piano note	15–30 db.
Hammer blow on metal plate	25 db.
Cough	20 db.

In regard to the physical design requirements, full consideration has been given to the matter of absolute freedom from overload and of reasonable portability. Overloading may have serious effects, such as that of decreasing the reading of the indicating meter. Low-frequency overloading ahead of the frequency weighting network may increase the meter reading. Ordinarily, overloading is most likely to take place in the vacuum tubes. The amplifier of this sound meter has been so designed that the only parts in which overloading might take place are the tube immediately preceding the weighting network and the tube operating into the rectifier. At these points overloading is negligible, frequencies as low as 20 cycles being measured at any point in the scale of the output meter without overloading, while the last amplifier tube can handle complex voltage waves, such as have been experienced in any ordinary type of noise. The meter is practically completely shielded against electrostatic fields, and, to a degree sufficient for the majority of cases, against electromagnetic fields. In most locations where intense electromagnetic fields are encountered, since the sound meter is readily movable, the electromagnetic effects can be met by properly orienting or locating the meter.

While the meter has been designed to be quite stable in regard to its initial calibration, a means of making an over-all calibration in the field has been included as part of the measuring equipment. This field calibrating set is designed for an over-all acoustic calibration, including the pick-up device, amplifiers, and indicating meter. The process of calibration is a simple one, requiring only a few seconds. The question of portability has been given primary consideration. For this reason, the meter is contained in one box, and the battery supply and calibrating equipment are contained in a second box, providing space for carrying the sound pick-up. Both units together are easily carried by one man. Fig. 2 shows one model of the instrument.

In addition to information as to the loudness of a noise, we are frequently interested in the quality of the noise. The quality, in general, depends upon the distribution in the frequency spectrum of the components of the noise and on the magnitude of these components. The musical tone produced by an organ pipe consists of a fundamental component and various so-called "overtones," which are components having harmonic relationships with the fundamental. The quality of the tone is dependent upon the relative values of the components present. It is frequently noticed that the noise of rotating machinery contains a "musical" note. This is easily explained by a study of the relationship of the components of the noise,

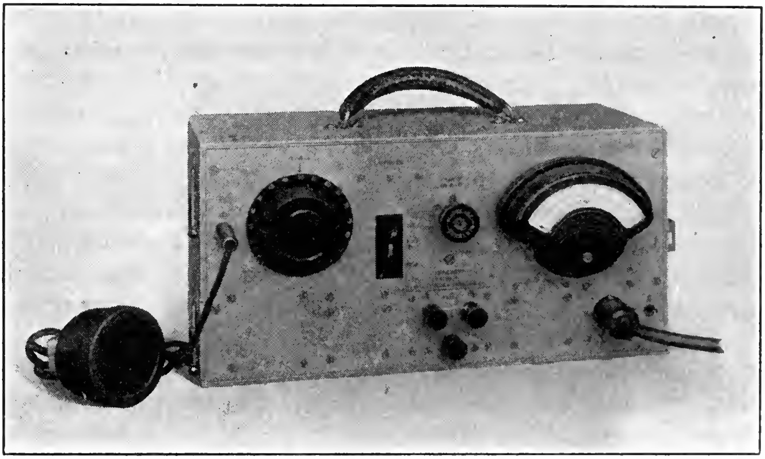

Fig. 2. One model of the sound meter.

which will show one or more fundamentals, each with a series of harmonics or "overtones." In some instances, the fundamental may be suppressed, and only the series of harmonics will be found. In addition, there may be other components which do not bear a harmonic relationship to any of the fundamentals. These are generally known as "transients;" *i. e.*, they are not regularly and continuously produced but occur only at intervals and are generally caused by impact or friction between surfaces. Certain other classes of noise, such as windage in rotating machinery, may be found, which manifests itself not as individual single frequency components but rather as a band of components. Information obtained by a resolution of

the noise into the above classes is of great value in determining the contributions to the noise of the different mechanical actions of the machine and in permitting design changes for the reduction of noise.

In composite noise, such as that encountered in a busy street, an enormous number of individual components bearing no definite relationship one to the other, may be found, being caused by the multiplicity of noise-making sources. The degree to which we are disturbed or annoyed by noise is dependent, in addition to the loudness, upon the quality of the noise and therefore a means of analyzing its characteristics is desirable.

The method of making the analysis of noise, and the accuracy with which each component should be selected, is dependent upon the requirements in the individual case. Where the investigator is primarily concerned with the effect of noise upon people, which factor generally includes the matter of personal annoyance, it is, in general, satisfactory if information is gathered concerning the loudness of the noise in bands throughout the frequency spectrum. Thus, all components below, for example, 500 cycles might be grouped together, and the loudness of these sounds measured independently. All components may then be grouped together in bands, say, from 500 to 1000 cycles, 1000 to 1500, *etc.* This information may be readily gathered and, as above stated, is helpful in determining the effect of the given noise in masking or interfering with speech reception and determining the probable annoyance value.

However, many studies are made for the purpose of reducing noise, and obviously the first step in such a study should be the determination of the specific sources of the noise. For studies of this nature on machinery, for example, a means of determining each component of the noise should be utilized in order that harmonic components may be connected with their fundamentals. Steady components not harmonically related to fundamentals associated with rotational or power frequencies may be assigned to vibration of parts of the apparatus and the "transient" components may be determined. Studies of this nature are invaluable in permitting a systematic engineering attack upon noise from any given equipment, supplanting the more usual cut-and-try method. Thus the amount of reduction to be obtained by elimination of any one component of the noise may be determined in advance.

With the sound meter which has been described above, an analyzer attachment is being developed which permits both broad-band and

relatively accurate single-frequency analysis. This analyzer attachment is quite portable, and is helpful for all studies requiring analysis sufficient for a determination of the physiological effects of noise, and is adequate for most machinery noise studies. Where additional information in the study of machinery noise is required, somewhat more elaborate and less portable apparatus may be required.

In any discussion of newly developed apparatus, it is necessary to point out certain limitations in its use. Noise is a complex quantity, and, regardless of the accuracy of instruments or the fidelity with which they record values corresponding to human perception, considerable care and thought must be used in the obtaining of data and in its interpretation. In the first place, it must be borne in mind that the measurements indicate conditions at the point of pick-up, that the instrument measures the total noise at that point, and does not have the human ability to differentiate between sounds. A human being is capable of detecting a particular sound in the presence of other and louder sounds, particularly if its character be considerably different from the interfering noises. The presence or absence of this particular sound may contribute no appreciable amount to the total loudness at the point of observation, although its presence or absence is noted by the ear. Obviously, an instrument indicating only total loudness will not detect the presence or absence of the least loud sound. It is therefore necessary, where the noise created by a particular source is to be measured, that there be no interfering noises; or, at least, that such interfering noises be sufficiently below the level of the sound to be measured, so that changes in their magnitude are negligible in comparison with the loudness of the sound being measured. In general, a difference in level of about 20 decibels is adequate for precise measurements, and a difference in level of about 10 decibels for most practical work.

Since the purpose of many noise measurements is to provide comparative information as to the noise created by different machines or the same machine under different conditions of operation, it is necessary to consider other factors in insuring comparable results. Among these many factors some of the most important are listed and briefly discussed below:

The distance and direction from the source must be carefully considered, particularly where the source is of a directive nature. The existence of standing waves produced by any steady component of the noise must be compensated for, as large differences in acoustic

pressure may exist at points separated by only a short distance. A satisfactory means of compensation for this phenomenon must be determined for each individual case, and is dependent upon the nature of the sound being measured and upon the acoustical condition of the surroundings. In determining the loudness of sound in an enclosure consideration must be given to the volume of the enclosure, whether the loudness is desired at a fixed point with respect to the source, or whether the average loudness throughout the enclosure should be obtained. In addition, the amount of acoustic absorption in the enclosure must be determined if results are to be comparable with those obtained elsewhere. Where information is to be obtained relative to the distribution of the acoustic energy through the audible spectrum, consideration must be given not only to the amount of acoustic absorption but also to the frequency characteristics of such absorption, as in determining the values of loudness in each frequency band allowance must be made for the value of the absorption in that particular frequency band.

The importance of listing in the data of noise measurements all pertinent factors, including those outlined above, cannot be overestimated. If all factors are known, it is generally possible to reduce the values obtained under any given conditions for purposes of approximate comparison with those obtained under different conditions. Thus, in the motion picture industry where the noise producing value of different pieces of apparatus, such as cameras, lights, ventilating systems, *etc.*, is a matter of great concern, agreement should be obtained as to proper conditions for measuring the noise of each type of equipment. These proper conditions should then be standardized and all data for comparative purposes should be obtained under such standardized conditions. In this manner, a wealth of information concerning the noise values of equipment may be obtained, which will in each case be strictly comparable with data obtained elsewhere. This should be of vast aid to the industry, since by study the limiting noise levels required for any situation may be determined and the applicability of any given piece of equipment immediately determined, or the degree of improvement required can be ascertained in definite numerical terms.

Acknowledgment is made of the use of considerable information from the paper, "An Indicating Meter for the Measurement and Analysis of Noise," by Messrs. T. G. Castner, E. Dietze, G. T. Stanton, and R. S. Tucker, presented at the Rochester District Meeting of the A. I. E. E., April 30, 1931.

A MOVING COIL MICROPHONE FOR HIGH QUALITY SOUND REPRODUCTION*

W. C. JONES AND L. W. GILES**

Summary.—*A microphone is described which retains all of the inherent advantages of the moving coil type of structure, but unlike the earlier forms of this microphone it responds uniformly to a wide range of frequencies. It is more efficient than the conventional form of condenser microphone and its transmission characteristics are unaffected by the changes in temperature, humidity, and barometric pressure. Unlike the condenser microphone, the moving coil microphone may be set up at a distance from the associated amplifier and efficient operation obtained. Owing to its higher efficiency and lower impedance it is less subject to interference from near-by circuits. It is of rugged construction, and when used in exposed positions is less subject to wind noise.*

Certain of the basic ideas underlying the moving coil or electrodynamic type of microphone were apparently conceived during the initial stages of the development of the telephone, for as early as 1877 the suggestion was made that the static force exerted on the diaphragm of Bell's electromagnetic microphone could be eliminated and its performance improved by making the diaphragm of non-magnetic material and attaching to it a coil, preferably of aluminum, so arranged as to vibrate in a magnetic field and generate a voltage in response to the sound pressure on the diaphragm.[1] The moving coil and electromagnetic microphones are, however, generators, and hence, their output cannot exceed the acoustical power available at their diaphragms. They did not, therefore, find extensive application in the telephone field, for the demand for instruments which would permit the extension of telephone service to longer distances soon led to the development and introduction of the carbon microphone, which is an amplifier and can be so designed as to deliver more power to the electrical circuit.[2] During recent years the introduction of the vacuum tube amplifier has reduced to a considerable extent the limitations imposed by the lower power output of the generator type of instrument, and attention has been turned to the moving coil

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Bell Telephone Laboratories, New York, N. Y.

microphone as an instrument suitable for high quality sound reproduction in connection with radio broadcasting, sound picture recording, and acoustic measurements in general.*[3,4,5,6]

It is the object of this paper to describe the construction and transmission characteristics of a moving coil microphone, shown in Fig. 1, which has been developed for this purpose.**[7] This microphone responds uniformly to a wide range of frequencies and is unaffected in its response by the changes in temperature, humidity, and barometric pressure encountered in using it.

Unlike the condenser microphone, it may be set up at a considerable distance from the associated amplifier, and, because of its higher efficiency and lower impedance, is less subject to interference from near-by circuits. It is of rugged construction and when used in exposed locations is less subject to wind noise than the condenser microphone. The use of a permanent magnet eliminates the necessity of providing a polarizing voltage.

Construction of the Microphone.—Although the early forms of the moving coil microphone possessed the advantages of absence of static force on the diaphragm, substantially uniform force factor and electrical impedance over a wide frequency range, and freedom from non-linear distortion even at large amplitudes, their response varied with frequency to such an extent as to make them unsuited for high-quality sound reproduction. This was due in general to two causes. In the first place the mechanical impedance of the diaphragm and coil varied widely with frequency, being high at the frequencies where the mass and stiffness reactances were the predominant factors, and relatively low in the region of the resonance frequency where the me-

* An electrodynamic microphone, often referred to as the ribbon microphone, has been developed by E. Gerlach and W. Schottky. In this microphone, an aluminum ribbon serves the dual purpose of electrical conductor and diaphragm. (See Reference 3.) An interesting application of the ribbon microphone to the problem of measuring the acoustic output of a telephone receiver is described in a paper by H. Carsten. (See Reference 4.) H. F. Olson presented a paper in which the theory of the ribbon microphone is discussed, and an instrument developed for high quality sound reproduction and directional pick-up is described. (See Reference 5.) A paper by B. A. G. Churcher and A. J. King discusses the application of the moving coil microphone to the measurement of noise. (See Reference 6.)

** This microphone is a commercial form of microphone developed by E. C. Wente and A. L. Thuras, the general principles of the design of which were described by them in a paper presented before the Acoustical Society of America. (See Reference 7.)

chanical resistance determined the magnitude of the impedance. Since the velocity imparted to the diaphragm and coil is directly proportional to the applied force and inversely proportional to their mechanical impedances, and since the voltage generated in the coil is directly proportional to the velocity of the coil in the magnetic field, it is evident that the response of such an instrument (*i. e.*, the open circuit voltage per bar, or per dyne per square centimeter pressure) would vary considerably with frequency, and would be characterized by a

FIG. 1. 618-*A* Type moving coil microphone.

prominent peak at the resonance frequency. In the second place, there was a tendency for the mode of vibration of the diaphragm to change at the higher frequencies and introduce additional irregularities in the response. In the microphone described in this paper the diaphragm has not only been so constructed as to reduce to a minimum the effect of changes in the mode of vibration, but several acoustical circuit elements have also been coupled to the diaphragm and coil in a manner such that the velocity imparted to the coil per

unit pressure of the actuating sound wave is substantially uniform throughout the frequency range of 35 to 10,000 cycles per second. A cross-sectional view of the microphone and its equivalent circuit are shown in Fig. 2.

The diaphragm is made of duralumin and has a dome-shaped center portion which extends to the inner edge of the moving coil. This stiffens the center of the diaphragm to an extent such that it vibrates substantially as a plunger throughout the frequency range of interest.

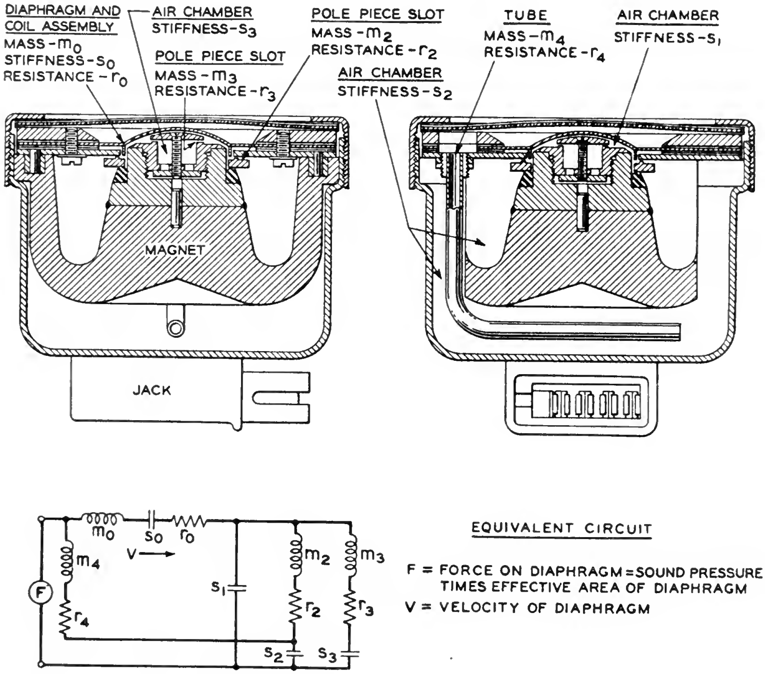

FIG. 2. Cross-section and equivalent circuit of the 618-*A* moving coil microphone.

The moving coil is composed of aluminum ribbon wound on edge and insulated with phenol varnish which also serves as a binder for holding the adjacent turns together.[8] The coil is fastened to the diaphragm with varnish, which is baked at a temperature sufficiently high to drive off the volatile material and insure a rigid bond between the adjoining surfaces. The effective mass, stiffness, and resistance of the coil and diaphragm assembly are represented in the circuit diagram, Fig. 2, by m_0, s_0, and r_0, respectively.

The diaphragm is clamped around the periphery by a ring which is so designed as to reduce the cavity in front of the diaphragm to a minimum. A magnetic field is established in the air-gap, in which the moving coil is located, by a permanent magnet made of cobalt steel. The magnetic properties of this alloy are such that the size of the magnet can be greatly reduced and demagnetization practically eliminated.[9] Concentric alignment of the pole-pieces is assured by welding the center pole-piece to the magnet and locating the outer one by means of pins fitted in soft iron inserts in the magnet.

A perforated metal grid covered with silk protects the diaphragm from injury. The grid and the metal housing of the instrument are insulated from the moving coil, and form a shield which may be connected to ground through one of the three contacts in the jack

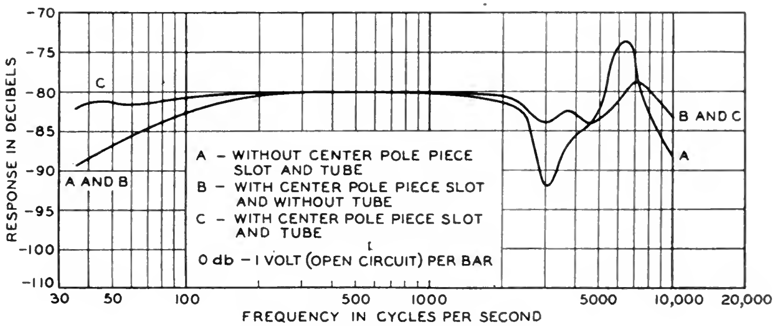

FIG. 3. Pressure calibrations of the 618-*A* moving coil microphone, showing the effect of the center pole-piece slot and the tube.

mounted on the back of the housing. The other contacts in the jack form the terminals of the moving coil. In order to reduce the contact resistance to a minimum a cam has been provided which presses the contact members tightly together after the plug has been inserted in the jack. This cam also serves as a lock to prevent the plug from being accidentally withdrawn from the jack while the microphone is in use.

When the diaphragm is displaced, there is an interchange of air between the cavity formed by the diaphragm and the pole-pieces and that enclosed by the housing. The connection between these cavities is a slot at the base of the coil which introduces a mechanical resistance (r_2) and the mass (m_2).[10] As is shown in Fig. 2, this slot is formed by clamping the projecting portions of a shim between a ring and the

outer pole-piece. The dimensions of the ring are such as to provide clearance between its inner diameter and the center pole-piece. Acoustic leakage at this point is prevented by a rubber gasket which seats on a shoulder on the center pole-piece and presses against the ring when the instrument is assembled. The resistance (r_2) and mass (m_2) of the slot, and the stiffness (s_2) of the cavity enclosed by the housing are coupled to the diaphragm by the stiffness (s_1) of the cavity between the diaphragm and pole-pieces.

The introduction of the mesh (r_2, m_2, s_2) practically eliminates the prominent resonance peak to which reference was made in the discussion of the response of the simple microphone in which the mass, stiffness, and resistance of the coil and diaphragm are the predominant factors in determining its mechanical impedance. Although the

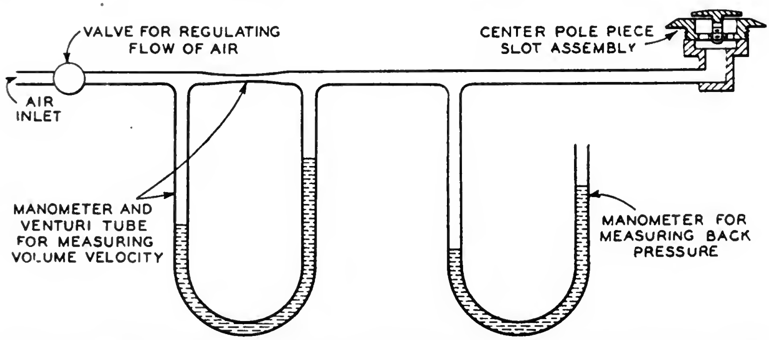

FIG. 4. Method of measuring the acoustical resistance of the pole-piece slots.

response obtained in this way (curve A, Fig. 3) is comparatively flat below 2000 cycles per second there is a large dip in the curve in the region of 3000 cycles, followed by a peak at 6000 cycles. A second acoustical mesh (r_3, m_3, s_3) has been added to correct these undesirable irregularities. As in the case of the mesh (r_2, m_2, s_2) this mesh is also coupled to the diaphragm by the stiffness s_1. It consists of a cavity in the center pole-piece having a stiffness (s_3) and a slot having a resistance (r_3) and a mass (m_3). The improvement in response resulting from the introduction of this mesh is shown by curve B, Fig. 3.

The center pole-piece and outer pole-piece slots are both so designed that they can be tested for acoustical resistance, and the necessary adjustments can be made before they are assembled in the microphone. The shim, cap, and shell, which form the center pole-piece slot, constitute a unit which after assembly is attached to a testing

fixture in the manner shown in Fig. 4, the air flow adjusted by means of a valve D, and readings of the manometers, A and B, noted. All that is required for inspection purposes is to make sure that for a given volume velocity of the air as indicated by the manometer A, the pressure drop across the slot as read on manometer B falls within the permissible limits. If this requirement is met the holes in the shell are closed and the unit is ready for assembly into the pole-piece. If the absolute value of the acoustical resistance is required it is necessary to calibrate the manometer A and to determine the resistance for several values of volume velocity. The velocities at which reasonably precise determinations of resistance can be made with a measuring device of this type are all much higher than those which result from the diaphragm displacements which occur in the actual use of the microphone, and introduce end effects for which a correction must be made. This is done by plotting the values of the resistance and air velocity, passing the best straight line through the points, and noting the intercept with the resistance axis.* A curve obtained in a test of a representative center pole-piece slot is shown in Fig. 5. The outer pole-piece slot can also be tested with the same type of fixture by providing a closure for the pole-piece opening so that the flow of air is confined to the slot. A typical curve obtained in a determination of the acoustical resistance of this slot is also shown in Fig. 5.

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* In connection with an investigation of the acoustical impedance of slots, holes, *etc.*, the results of which have not yet been published, A. E. Swickard of the Bell Laboratories, has pointed out that the relation between the apparent acoustical resistance obtained in the manner described above and the volume velocity is given by the following equation:

$$R = \frac{12\mu l}{wd^3} + \frac{\rho Q}{2(cA)^2}$$

where R = acoustical resistance of the slot
μ = viscosity coefficient of air
l = length of the slot
w = width of the slot
d = thickness of the slot
ρ = density of air
A = area of the slot entrance
Q = volume velocity
c = a coefficient which takes into account the effect of contraction, expansion, and turbulence of the air stream.

From this equation it is evident that the relation between the apparent acoustical resistance and the volume velocity is a straight line, and the intercept is the absolute value of the resistance, $\frac{12\mu l}{wd^3}$. (Ref. 10.)

As is shown by curve B, Fig. 3, the response of a microphone consisting of two acoustical meshes, coupled to the diaphragm and coil by means of a cavity stiffness, drops off at the low frequencies due to the stiffnesses (s_0) of the diaphragm and (s_2) of the cavity enclosed by the microphone housing. The effect of the latter can be reduced by increasing the size of the cavity, but there is a limit to the extent to which the stiffness of the diaphragm can be decreased without sacrificing stability and mechanical ruggedness. The response at the low frequencies can, however, be materially improved and a rugged dia-

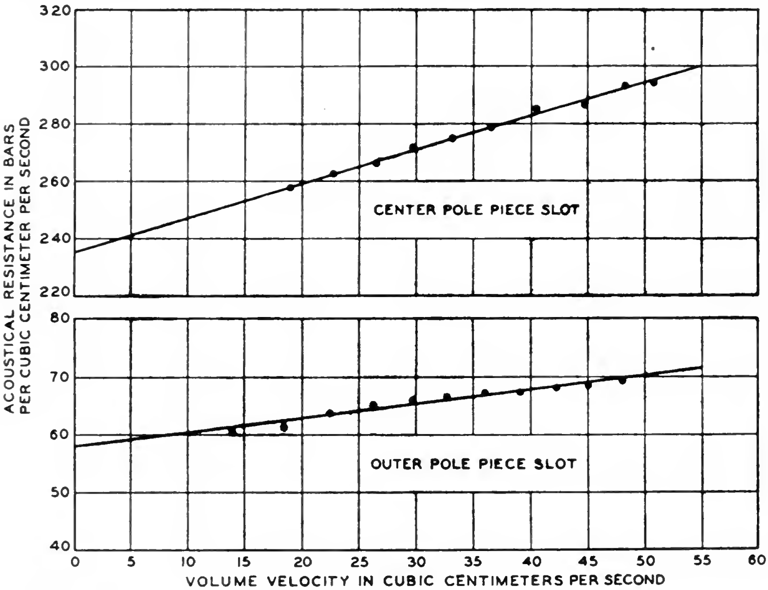

FIG. 5. Curves showing the relation between the acoustical resistance of the pole-piece slots and volume velocity.

phragm structure can be obtained by the simple expedient of coupling the cavity enclosed by the microphone housing to the outside air by means of a tube. The introduction of the tube results in a pressure within the housing which at these frequencies is of such a magnitude and phase as to increase the effective pressure on the diaphragm. The improvement in response effected by the introduction of the tube is shown by curve C, Fig. 4. The mass and resistance of the tube are represented in the equivalent circuit diagram by m_4 and r_4, respectively, and both quantities vary to a certain extent with frequency.[11]

Field and Pressure Calibrations.—The response curves (Fig. 3) are pressure calibrations, *i. e.*, the response was obtained with a constant sound pressure on the diaphragm without taking into account the effects of diffraction and angle of incidence of the sound wave. The effects of these factors are, however, included in the field calibrations (Fig. 6) which give the response for various angles of approach of the sound wave when the microphone is inserted in a sound field of constant pressure. It is evident from these curves that the diffraction of the sound wave around the microphone and the angle of incidence of the wave both have a marked reaction on the response of the instrument at frequencies above 1000 cycles per second. The possibility of decreasing these effects by reducing the size of the microphone was considered during its development, but the dimensions

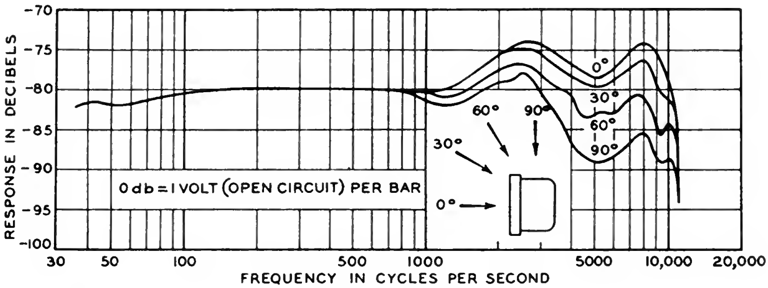

FIG. 6. Field calibrations of the 618-*A* moving coil microphone, showing the effect of the angle of incidence of the sound wave.

required to remove them from the frequency range of interest involved transmission and structural difficulties which were prohibitive. The relation between the pressure and field calibrations of a microphone and its characteristics under conditions of actual use have been discussed in detail in papers dealing with the response of the condenser microphone.[12,13] The conclusions reached may be summarized as follows:

There are certain uses to which a microphone is put where the conditions agree quite closely with those assumed in the pressure calibration, as for example, when it is coupled directly to another instrument, as is often done in the calibration of a telephone receiver. If, on the other hand, the microphone is placed in a sound field of uniform intensity the pressure acting on its diaphragm may depart widely from a constant value in certain frequency ranges, the magni-

tude of the departure depending not only upon the microphone itself but also upon the nature of the sound source, the position of the microphone relative to the sound source, the configuration and acoustic properties of the reflecting surfaces which surround the microphone, *etc.* If the microphone is so located relative to the source of sound that the direct waves predominate and standing waves are not set up between the microphone and the source, the response will usually agree with the normal incidence field calibration. The acoustic conditions in most indoor work are, however, such that much of the sound reaches the diaphragm of the microphone by way of reflection from walls and surrounding objects, with the result that the direction of approach of the sound cannot be considered as normal to the plane of the diaphragm. In addition, the characteristics of the reflected sound are modified by the acoustic properties of the reflecting surfaces. Under these conditions the effective angle of incidence is somewhere between 0 and 90 degrees. The acoustic conditions encountered in the practical use of a microphone vary so widely that no single response curve can be considered as representative of its performance under all conditions of use. This is even more evident when it is recalled that the data from which these curves are plotted are secured after steady state conditions have been established. It is obvious, therefore, that although the response curve serves a useful purpose in indicating the kind of performance to be expected with a given instrument when operating under the conditions of the test, it must be interpreted in the light of the similarity of the test conditions and those which exist in each individual application. If the microphone is to be used for precise quantitative acoustic measurements a calibration should, of course, be made under the actual conditions of use.

The mechanical impedance of the moving coil microphone is so low that the stiffness of the cavity required to obtain a satisfactory calibration by the thermophone method[14] has a marked reaction on the response obtained. All the response data reported in this paper were taken, therefore, in the following manner: The moving coil microphone and a condenser microphone which had previously been calibrated by the thermophone method were set up, as shown in Fig. 7, at a distance of approximately seven feet from a sound source in a damped room having a reverberation time of approximately 0.1 second. The sound source consisted of two loud speaking receivers mounted in a baffle, which was arranged to rotate in a circle and al-

ways to face the microphones under test. One of the loud speaking receivers was a moving coil instrument of the direct radiator type, which served as a sound source for frequencies between 150 and 3000 cycles per second. The frequencies above 3000 cycles per second were supplied by a special moving coil receiver with a short horn so designed as to be an efficient source of sound up to 12,000 cycles per second.[15] Difficulty was experienced at frequencies below 150 cycles per second in obtaining sufficient pressure at the microphone with the sound source just described. This difficulty was overcome, however, by coupling the microphones more closely to another sound source in the manner shown in Fig. 7. Satisfactory sound pressures were ob-

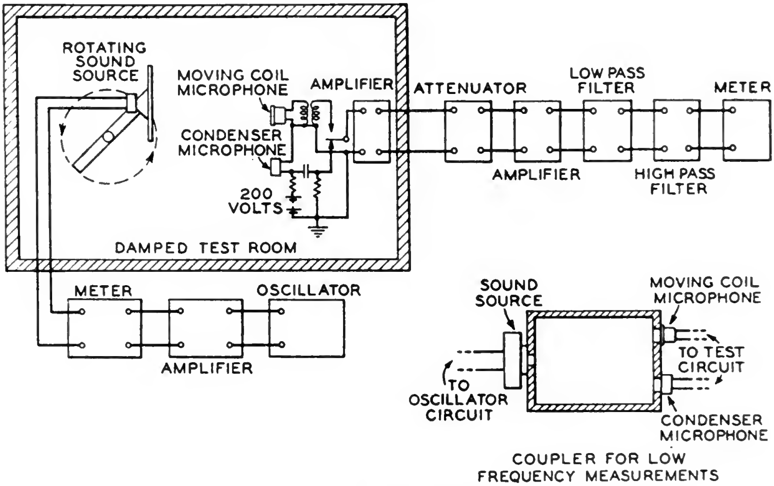

FIG. 7. Response measuring circuit.

tained in this way at frequencies as low as 35 cycles per second. A field calibration of the condenser microphone under the conditions of actual use in the test room was then made. This calibration was obtained by first measuring the intensity of the sound field by means of a small condenser microphone one inch in diameter and a small electromagnetic microphone three-quarters of an inch in diameter and, after these measurements had been completed, by inserting the condenser microphone in the sound field and determining the voltage developed. The difference between the pressure and field calibrations of the condenser microphone is shown in Fig. 8, together with similar data obtained by other methods of measurement. The close

agreement among these curves justifies the conclusion that although the measurements were made in a comparatively small room the amount of sound reaching the microphone by way of reflection was negligible, and that a response curve obtained in this way is a normal incidence field calibration. The oscillator was then set at the desired frequency and the current supplied to the sound source was adjusted to a value such that the voltage developed by the condenser microphone gave approximately a mid-scale reading of the meter in the measuring circuit. For convenience this meter was calibrated in decibels. The moving coil microphone was then connected to the measuring circuit, and the attentuator was adjusted until the meter reading was approximately the same as that obtained with the condenser microphone. The difference between the output of the

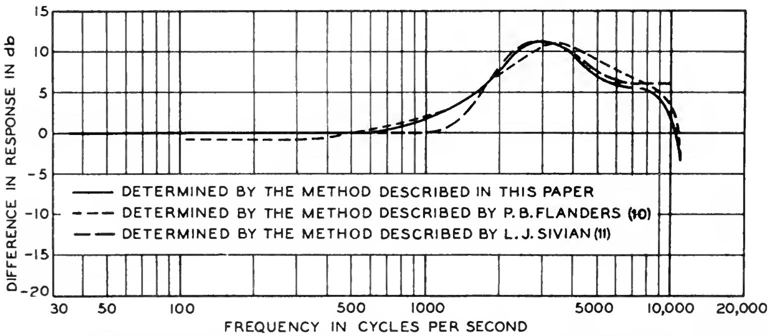

FIG. 8. Difference between the normal incidence field and the pressure calibrations of the 394 type condenser microphone.

two microphones was then determined from the attentuator and meter readings. In order to correct for possible differences in the intensity of the sound field at the positions where the microphones were placed, the instruments were interchanged and a second determination of the difference in response was made. With the exception of the frequency range in the region of 800 to 3000 cycles per second no difference was found in the response in the two positions. The maximum deviation in this frequency band was of the order of 2 db. In order that the diffraction of the sound around the two microphones should be as nearly identical as possible, the back of the condenser microphone was built to have the same contour as the moving coil microphone. Subsequent data showed that, in general, this refinement was unnecessary. The field calibration of the moving

coil microphone was determined from these data by adding to or subtracting from the field calibration of the condenser microphone the differences in the response of the two instruments.

The pressure calibrations of the moving coil microphone were obtained by securing a field calibration with the face of the instrument built to provide a cavity of the same diameter and depth as that of the condenser microphone, and correcting this curve by the observed difference between the field and pressure calibrations of the condenser microphone. This method of calibration does not take into account the difference in the impedance and shape of the diaphragms. Although quantitative information is not available at present relative to the influence which these differences exert on the response obtained, it is believed that their effect is not large.

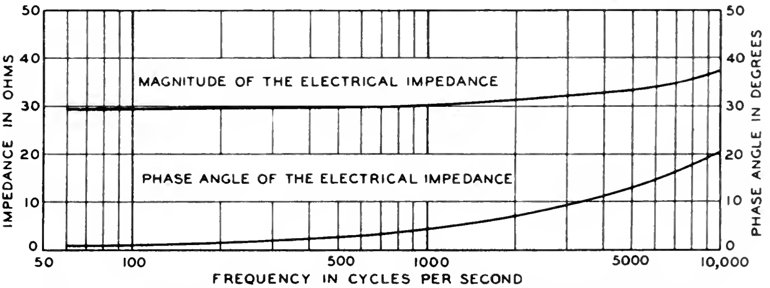

FIG. 9. Electrical impedance of the 618-*A* moving coil microphone.

The effect of the angle of incidence of the sound wave on the response was determined by setting the microphone at the angles designated in Fig. 6 and noting the difference in response as compared with that obtained when the microphone faced the sound source.

Effect of Changes in Temperature, Humidity, and Barometric Pressure.—The response of the moving coil microphone is independent of the changes in temperature which are likely to be encountered in its use. In reaching this conclusion response data were secured at temperatures ranging from 50 degrees below zero to 130 degrees above zero Fahrenheit. The maximum deviation from the response at room temperature observed during these tests was of the order of 1.5 db. Differences of this magnitude are within the precision of the test.

The tube which was introduced to improve the response at the low frequencies also provides means for equalizing the barometric pressure

in front and back of the diaphragm, and eliminates the effect on the response of the microphone of the changes in barometric pressure which occur from time to time.

During the development of the moving coil microphone, representative samples were tested for the effect of humidity by placing them in

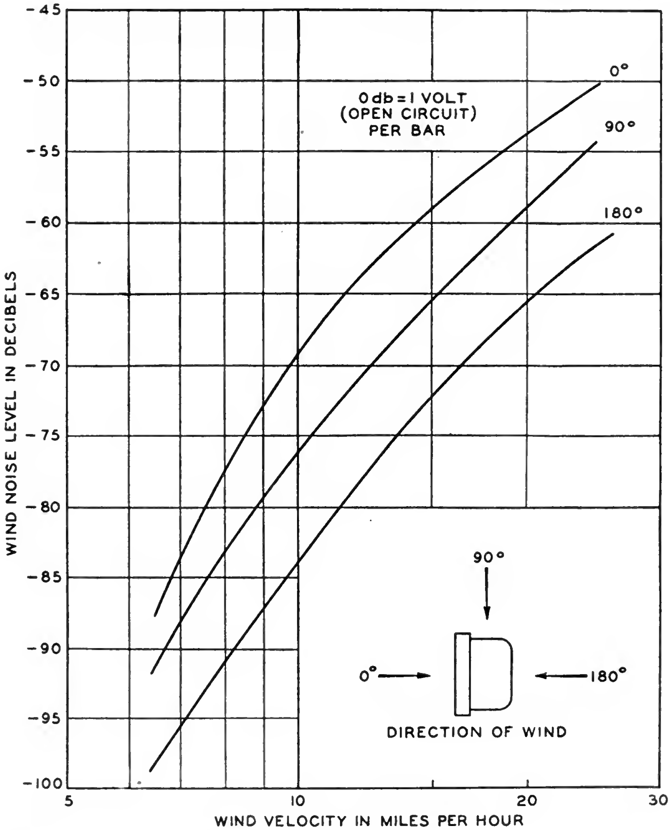

FIG. 10. Curves showing the relation between the level of the wind noise, and the velocity and direction of the wind.

a room in which the relative humidity of the air was maintained at 90 per cent. No change in the transmission characteristics of the instruments was observed after they had been subjected continuously to these rather severe atmospheric conditions for a number of days. All the metal parts are protected from corrosion by suitable finishes.

The electrical impedance and phase angle of a representative mov-

ing coil microphone are shown in Fig. 9. The slight increase in impedance occurring at the higher frequencies is due to the reactance of the coil and the increase in the effective resistance resulting from eddy currents in the pole faces and diaphragm.

Wind Noise.—Laboratory tests for wind noise show the noise level of the moving coil microphone to be approximately 6 db. lower than that obtained with the 394 type condenser microphone at wind velocities of 20 to 30 miles per hour. At lower velocities the difference is from 5 to 10 db. greater. Typical wind noise curves for three angular positions of the microphone are shown in Fig. 10. These curves were obtained by placing the microphone in an air stream having a uniform velocity. They do not, therefore, take into account the effect of the sudden changes in velocity which are characteristic of the wind conditions often encountered in practice.

Conclusion.—Although there are certain desirable characteristics, such as absence of static force on the diaphragm, constancy of force factor and electrical impedance, freedom from non-linear distortion, *etc.*, which are inherent in the moving coil type of microphone, the response of the earlier forms of this instrument varied to such an extent with frequency as to make them unsuited for high quality sound reproduction. It has, however, proved feasible to retain the desirable characteristics of the moving coil structure and obtain substantially uniform response over the frequency range of 35 to 10,000 cycles per second by associating several acoustical impedances with the mechanical impedance of the diaphragm in the manner described in this paper. During the development of this microphone consideration was also given to reducing its size sufficiently to make its response, throughout this frequency range, independent of the angle of incidence and diffraction of the sound wave, but the transmission and structural difficulties encountered proved prohibitive. External dimensions and acoustical and mechanical constants were, therefore, chosen for the instrument such that its response at the frequencies at which diffraction and angle of incidence are of importance, is substantially uniform under the conditions most likely to be encountered in its use. In this connection it should be borne in mind that the response obtained is not only dependent upon the characteristics of the microphone but also upon the nature of the sound source, the position of the microphone relative to the sound source, the configuration and acoustical properties of the reflecting surfaces which surround the microphone, *etc.*, and that data relative to the response

of a microphone must in each instance be interpreted in the light of the conditions under which it is to be used.

The efficiency of the moving coil microphone described in this paper is higher than that of the conventional form of condenser microphone, and its transmission characteristics are unaffected by the changes in temperature, humidity, and barometric pressure likely to be encountered in its use. It can be set up at a considerable distance from its associated amplifier, and, because of its higher efficiency and lower impedance, it is less subject to interference from near-by circuits than the condenser microphone. It is of rugged construction and when used in exposed locations is less subject to wind noise than the condenser microphone.

A number of moving coil microphones of this type are now in use and the results obtained are, in general, in agreement with the conclusions reached in this paper.

We are indebted to Messrs. T. E. Davis, R. C. Miner, and R. N. Marshall, of the Bell Telephone Laboratories, for their assistance in obtaining much of the data presented in this paper.

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AN APERTURELESS OPTICAL SYSTEM FOR SOUND ON FILM*

R. C. BURT**

Summary.—*An optical system which uses positive and negative cylindrical lenses with their axes at right angles is described. The image of a source is optically elongated and flattened by these cylindrical lenses to the proportions desired, and is then focused on the film. Advantages are: maximum possible brilliancy with a given source temperature; not sensitive to position of the lamp filament; sharpness of image; and intrinsically perfectly uniform brilliance throughout the length of the beam.*

The ordinary optical system for the reproduction of sound from records on film requires some form of limiting mechanical aperture of special shape. It is shown in this paper that not only is the use of such a mechanical aperture not necessary, but the apertureless system herein described has desirable features not obtainable with any other system. In this optical system the image of a finite source of light is optically flattened and elongated until it is in the proper proportion for the light beam on the film. This image is then focused on the film by an achromatic lens.

As shown in Fig. 1, this result is obtained by using special lenses. In an elementary system two of these lenses have cylindrical surfaces. One surface is negative, its axis being horizontal; the other surface is positive, its axis being vertical. The negative surface reduces the thickness of the filament image, and the positive surface draws out its length.

Fig. 2 is a vertical section in which

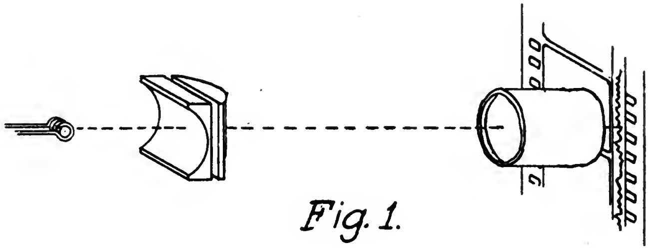
S is the source
J is the virtual image of the source
N is the negative surface
P is the positive surface
O is the objective
F is the film
I is the image on the film

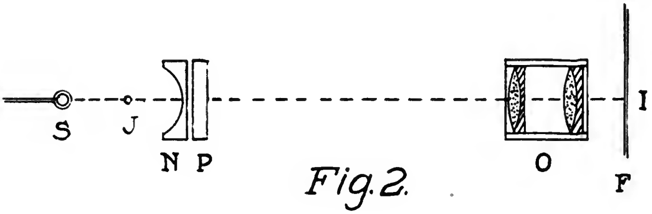
* Presented in the Symposium on Theater Practices, at the Spring, 1931, Meeting at Hollywood, Calif.

** Pasadena, Calif.

It is evident that by properly selecting the power of the negative lens, the virtual image J can be made any desired size so that with a given objective lens, it will be reduced to the desired width at I.

Fig. 3 shows the plan section. Each element of the filament is drawn out by the positive lens P until, when observed from the





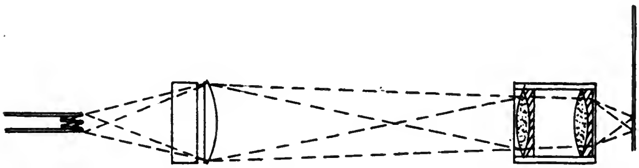


Fig. 3.

FIG. 1. Optical train of the apertureless system.
FIG. 2. Vertical section of Fig. 1, showing the various elements.
FIG. 3. The plan section, illustrating the focusing of elements of the filament, forming a striated vertical band which completely fills the objective.

objective, it appears as a long bar of light extending completely across the lens P. Light from each element is then brought to focus at a point on the objective. This appears as an image of the filament along one axis only, being a striated vertical band of light which completely fills the objective. It is obvious that instead

of one lens of given power, several lenses of lower power can be substituted.

In applying this optical system almost any available source of light may be used, and by properly selecting N and P any desired size of beam may be formed. The length and width of the light beam required on the film, and the light source which it is desired to use are usually fixed. Given the length of the light beam, the fastest short focus objective commercially available is selected. Usually a microscope objective is satisfactory, as these are inex-

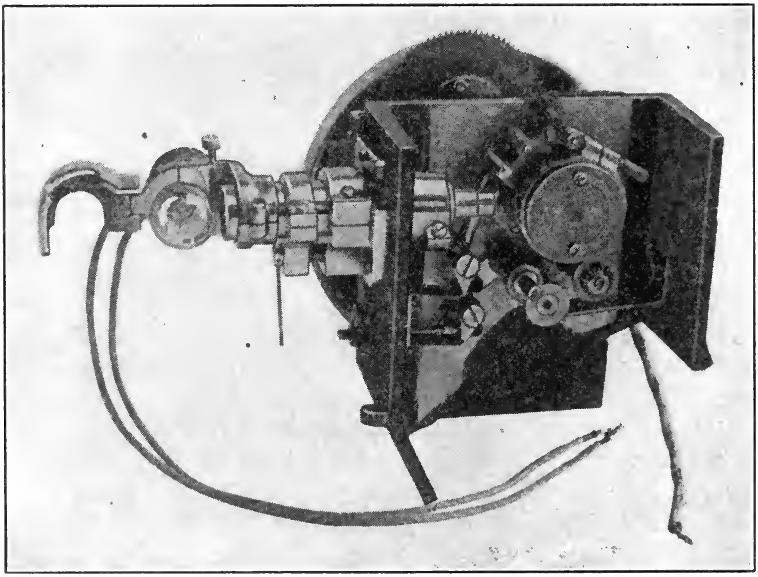


FIG. 4. Photograph of the optical system.

pensive, highly corrected, and have speeds up to $f/1.0$ or greater. Selection of such a lens automatically places limits on the location of the image J, as these lenses are corrected for a certain working distance and this in turn determines the size of J.

Selection of the power and location of the lens element P comes next because, knowing the length of the selected source, P is chosen so as to fill the objective O completely with light of intrinsic brilliancy, thus obtaining the highest efficiency.

The length of the negative lens N is now determined to give the

required length of image I and it is only necessary to compute N for the proper reduction of diameter of S to meet the specified value needed for J.

The mathematical solution of the above conditions is very elementary, requiring only the simple lens equation. Solution by maxima and minima for the shortest possible optical system with a given set of lens O and N is difficult, a graphical solution being much easier. The advantages of this system in comparison with others are easily understood and may be enumerated as follows:

1. A glance at Fig. 3 shows one that the objective O is completely filled at all points by light of intrinsic brilliancy from all points on the image J. Hence the system is 100 per cent efficient, giving the maximum brilliance possible in the image I for any system using a source of light S and passing it through any lens. The only way a more brilliant image can be obtained is by using a faster lens at O or by increasing the temperature of the source S.

2. It is not sensitive to position of the filament. Referring to Fig. 2, S may move up or down, forward or backward, with only a small change in the position of J, due to the effect of the lens N. As a result of this feature a standard source such as an automobile headlight bulb is perfectly satisfactory. Once designed, all standard headlight bulbs are perfectly interchangeable without any refocusing whatever.

3. The effect of azimuth errors in the filament do not appear as an inclined light image, but only as a very slightly broadened image. When using an automobile headlight bulb, the filament coil may be rotated 30 degrees from the horizontal and the light image width is increased only 60 per cent.

4. The image is very sharp, clean, and true, being formed by an optical surface instead of a mechanical slit as is the usual custom.

5. The most unique and important of all advantages is the fact that the light beam is perfectly uniform in intensity throughout its length. As will be evident from Fig. 3, this result is achieved because the horizontal image of the filament, which is composed of the coil elements, is focused on the objective O and consequently cannot possibly be in focus on the film. Furthermore, each coil element is drawn out by the positive lens P and is focused by the objective lens O upon the film, making a complete light beam in itself. It is the sum total of all such elements added together on the same line that make the fine, clear, brilliant image obtained.

This uniformity of light across the image makes a finer reproduction especially in the case of variable width recording, where variations in brilliance along the slit cause volume or harmonic distortions for which it is impossible to compensate.

DISCUSSION

MR. PALMER: I should like to know if Mr. Burt has any figures on the efficiency of his system. Can more light be gotten on film from the same light source than from the slit system?

MR. BURT: We can get considerably more light than with a slit system. No figure of the efficiency of the slit system is available, and we cannot calculate the theoretical efficiency of a slit; but we have measured slit systems, and have found that the slitless system is about 4 times as efficient. The efficiency of this system is determined by the speed of the lens, *O*, and the intensity of the source, *S*. More light cannot be obtained from any optical system which uses a projection lens than from this system because the lens *O* is completely filled with light. Consequently, the amount of light that can strike the film is determined by the angle of the lens and the brilliancy of the source. If you trace out the light rays from all points on lens *O*, the filament *S* appears of intrinsic brilliancy throughout the field.

MR. PALMER: How about using this for recording and getting an image of a glow lamp?

MR. BURT: In a Movietone recording lamp, about 90 per cent of the illumination comes from a little tube around that element approximately 0.125 to 0.25 inch in diameter and of a length from 0.25 to 0.5 inch. It becomes a problem to take illumination of that size and put it on the film in the form of a slit. We find that with an optical system 13 inches long, we can do it with one lens with a negative curvature on one side and a positive curvature on the other side, and reduce the image to a virtual image 0.006 inch in diameter and stretch it out to a length 6.125 inches long; and then focus this on the film 0.187 inch in length by 0.000085 inch in thickness.

MR. SHEA: With respect to the lamp problem it should be said that a great deal of development work has been done by lamp manufacturers during the last few years, and they have designed improved lamps for sound picture recording and reproduction. The efficiency of the lamp (its power consumption with respect to the light emitted) and the maintenance of high color temperatures over long periods of time, and the uniformity of the illumination across the filament are important factors. I want to make a plea, therefore, even if one has a good optical system, for using an equally good lamp.

MR. BURT: When we were first working out this optical system the regular exciting lamps were difficult to obtain except by those licensed. We therefore had to use the best source at hand and to design our system around it. The automobile headlight filament is V-shaped and only rarely does one get a lamp out of line by so much as 10 degrees. We feel that the optics of this system are fundamentally sound for any light source. Furthermore, it is possible to make use of lamps with very small filaments because we have an optical system here which can make efficient use of any filament we start out with. Fig. 5 shows a

negative made by projecting the image through a microscope objective, enlarging it to 1000 diameters.

MR. LARSON: Have measurements of frequency response been made? What have the results been with respect to the high frequency range?

MR. BURT: Theoretically, there is a slight limitation to the angle which can be used in an objective lens. If the angle gets too high, or if you use lenses which are super-fast, such as lenses of $f/1.5$, we get such large angles that the scattering is increased. This is true of all optical systems. So far as this optical system is concerned we can make the image on the film any degree of fineness desired. They have been made 0.0001 inch in width. In an actual test, one of

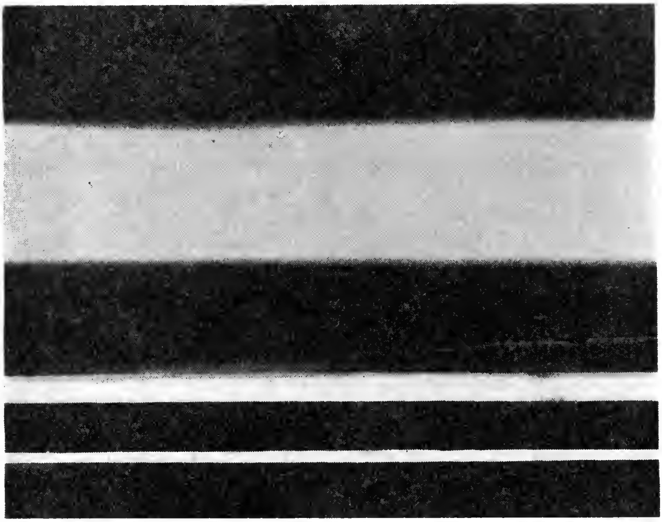


FIG. 5. The upper photograph is made by projecting the beam image through a 16-mm. microscope objective a distance of 16 meters to a photographic plate, and represents a small section of the image magnified 1000 diameters. The lower photograph represents a longer section of the image magnified 70 diameters. (Plates and prints are unretouched.)

the studios made a film experimentally which had a 15,000-cycle note recorded on it. The level was a little low, but it was put in a standard sound head using a slitless optical system, and we ran the film through. We took the current out of the head amplifier and passed it into a Bedell-Reich stabilized oscilloscope, and made the image stand perfectly still. We then examined the form of the 15,000-cycle sound wave and found it to be as good as that of the usual 60 cycle line voltage.

MR. FOSTER: What is the angle of the microscope between the axis of the lens and the end of the image?

MR. BURT: That depends upon the selection of the lens, the diameter of the lens, and its focal length.

Mr. Foster: Is there any difficulty due to curvature of field?

Mr. Burt: No. Microscope lenses are corrected for flat field.

Mr. Foster: Is there any falling off in the intensity due to the diminishing of the aperture of the lens as you approach the end of the lens?

Mr. Burt: That is the thing that determines in these lenses what their correct field is. We are using a 16-mm. lens in order to cover a 2-mm. length. We do this in order to use the highly corrected center part of the field. We can make that angle as small as we want. Ordinarily for commercial work we select short lenses. In working with Fox they wanted a 0.25 inch length, so we had to make a longer focus lens in order to get a corrected field.

REDUCING AND INTENSIFYING SOLUTIONS FOR MOTION PICTURE FILM*

J. I. CRABTREE AND L. E. MUEHLER**

Summary.—*The properties of a large number of known intensifying and reducing solutions have been studied in detail to determine formulas suitable for use with motion picture film.*

For intensification, the chromium, Monckhoven (mercury), and silver intensifiers were the most satisfactory. The Monckhoven intensifier is useful for extreme intensification where permanence is not essential and the chromium intensifier is suitable for negatives where a medium increase in contrast is desirable. The degree of intensification with the chromium method may be controlled within limits by a variation of the time of redevelopment. For negatives and projection prints, intensification with silver has been found to give strictly neutral images and the process permits of easy control of the degree of intensification. So far as is known, both the chromium and silver intensified images are stable.

For subtractive reduction, such as in the case of overexposures or fogged images, the use of either (1) a two-bath formula comprising separate solutions of potassium ferricyanide and sodium thiosulfate, or (2) a modification of the Belitzski reducer is suitable. Where proportional reduction is required, a solution containing ferric ammonium sulfate with sulfuric acid is recommended.

It has been found that the above methods of intensification and reduction are applicable to sound film with the possible exception of subtractive reduction which, by virtue of the lowering of resolving power, causes a loss of high frequencies.

The purpose of intensifying or reducing motion picture film is either to increase or decrease the density of the various tones of the image so as to modify the printing characteristics of the negative, or to improve the quality of the projection positive.

Negatives obtained by modern methods of control in the studio and laboratory, however, rarely require modification although in the case of picture negatives which are to be printed in conjunction with a sound negative, the contrast of the picture negative should be such that, when the positive is developed to a predetermined gamma,

* Presented in the Symposium on Laboratory Practices at the Spring, 1931, Meeting at Hollywood, Calif. Communication No. 473 from the Kodak Research Laboratories.

** Eastman Kodak Co., Rochester, N. Y.

correct picture quality will be obtained. In such cases, modification of the contrast of the picture negative is frequently desirable.

It is also sometimes possible to save a positive print which is otherwise too dense or contrasty or too weak and flat by suitable intensification or reduction.

INTENSIFICATION

The object of intensification is to increase the contrast of the image by increasing the effective photographic density of each silver grain.

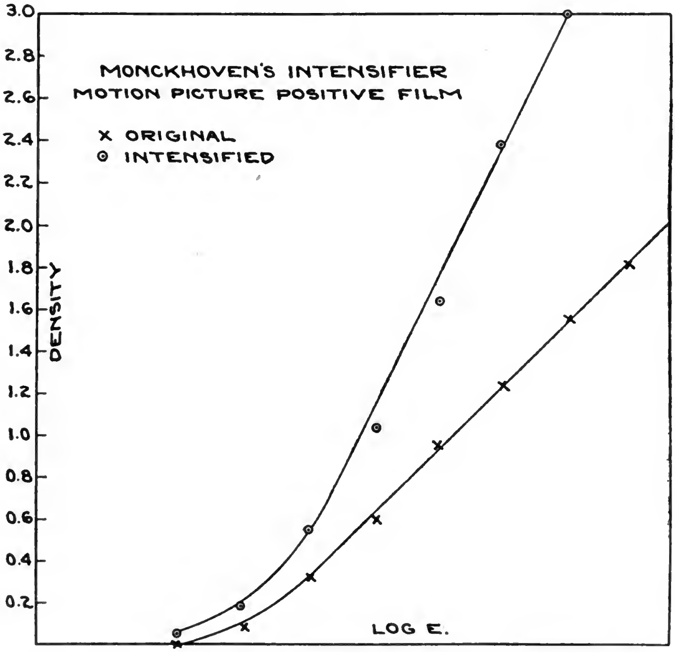


FIG. 1. Curves showing the effect of proportional intensification on a typical H & D curve.

The effect of proportional intensification on a typical H & D curve is shown in Fig. 1. The effect of intensification in increasing the printing contrast of the negative is shown in Fig. 2. Suppose ABC represents the H & D curve of the positive film developed to as high a degree as possible (gamma infinity). If the density scale of the negative is represented by the corresponding exposure scale, PQ, (log E units), the density scale of the print will be D_1D_2 which may

not be sufficient. If the negative is now intensified so that the density scale is increased and the resulting exposure scale is increased to PR, the density scale of the print is increased to D_1D_3.

Classification of Intensifiers.—Intensifiers may be classified according to the chemical reactions involved, which are as follows:

(1) The silver image is alloyed with mercury.
(2) A neutral or colored compound is deposited on the silver image.
(3) The silver image is more or less replaced by a colored compound of silver, a colored compound of another metal, or a dye.
(4) Metallic silver is deposited on the silver grains.

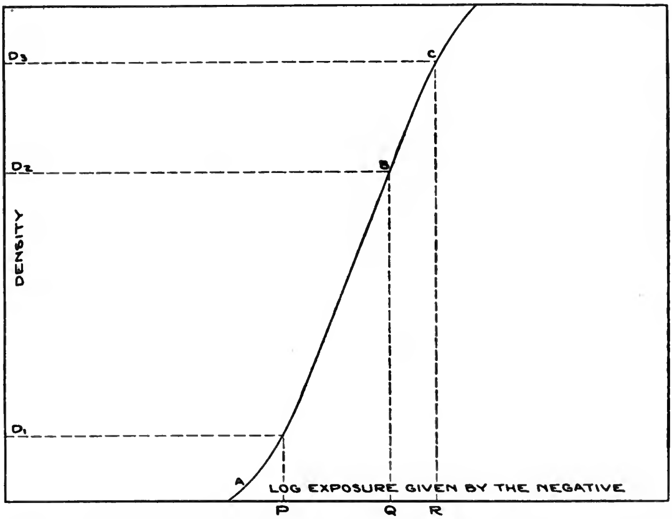


FIG. 2. Effect of intensification in increasing the printing contrast of the negative.

(1) This method involves bleaching the silver to silver mercurous-halide,[1] by means of a solution of mercuric chloride or bromide, and redeveloping the bleached image with an ordinary photographic developer, a solution of ferrous oxalate, sodium sulfite or ammonia, although many other solutions for redeveloping have been suggested.[2] A familiar method of obtaining a high degree of intensification with mercury is by the use of the so-called Monckhoven's intensifier whereby the redevelopment of the bleached image is accomplished by treatment with a solution of silver potassium cyanide.

There has always been some question as to the permanence or

stability of the image obtained by mercury intensification,[3] particularly when developers such as ammonia and sodium sulfite have been used. Mercury intensifiers are also objectionable because of the toxic character of the solutions used.

(2) The second type of intensification may be illustrated by the chromium intensifier. So far as is known, the resulting image is permanent, while the solutions used are relatively non-toxic. The process consists of bleaching the silver image in a dilute solution of potassium dichromate and hydrochloric or hydrobromic acid whereby the silver is converted to silver halide and a reduction compound of the dichromate is added to the silver halide grains. The image is then washed to remove the excess dichromate and is redeveloped with a suitable amidol or elon-hydroquinone developer. The chromium intensifier is one of the most suitable of the various types for motion picture work.

(3) Intensifiers in this class are identical with the solutions used for the toning of motion picture film whereby the silver image is more or less replaced by a colored inorganic compound or a dye. Typical colored inorganic compounds are silver sulfide and the ferrocyanides of lead, uranium, and copper. Certain of these inorganic salts act as mordants for basic dyes so that the toned image can be further intensified by immersing in a basic dye solution.

(4) The fourth type depends upon the fact that if a silver image is placed in a solution in which particles of metallic silver are being precipitated, the silver particles tend to deposit preferentially on the silver grains of the image thereby proportionally increasing the density of the silver deposit. Such intensifiers may be prepared by adding a chemical-reducing agent such as elon to an acid solution of silver nitrate. The resulting image is permanent, the degree of intensification is easily controlled, and the color of the deposit is visually neutral.

Intensifiers Suitable for Motion Picture Work.—In making a selection of the most suitable intensifiers for motion picture work the following criteria were considered:

(1) The intensifier should preferably give a neutral (non-colored) image.
(2) The intensification should be proportional or nearly so, and should be easily controlled.
(3) The solutions should be reasonably stable and relatively non-toxic.
(4) The intensified image should be permanent.

As a result of the survey, the chromium and silver intensifiers were

selected as conforming closely to the above requirements. In spite of the cited objections, for certain types of work the mercury intensifier has no equal. The high degree of intensification possible with one treatment with the Monckhoven's mercury intensifier is shown by the characteristic H & D curve in Fig. 1 where the average density increase is 100 per cent.

EXPERIMENTAL METHODS

Sensitometric Data.—A series of matched sensitometric step tablets, each 1 foot in length and made on motion picture positive film, were assembled in a loop and used as a negative on a continuous printer for printing 200-foot lengths of Eastman motion picture positive and motion picture panchromatic negative film. The positive and negative films were developed for relatively short times in the D-16 and the D-76 developers, respectively.

The films before intensification were hardened by treating for 5 minutes in the following solution followed by a short wash to remove the soluble chemicals.

Commercial formalin (40 per cent)	10 cc.
Sodium carbonate (desiccated)	5 grams
Water to make	1 liter

The strips were then treated with the intensifying solutions in photographic trays which were continuously rocked during treatment.

Color Coefficient.—In order to evaluate the relative merits of various intensifiers it is necessary to take into account both the visual and the photographic densities.

The methods used for the measurements of the properties of the various intensifiers described in this paper are based upon the principles presented by Jones and Wilsey[4] and Nietz and Huse.[5] A relative rather than an absolute measure of the photographic contrast of the intensified negative as compared with the visual contrast of the same negative was obtained in the following manner.

Strips of motion picture panchromatic negative film having equal step exposures were developed in the D-76 borax developer for increasing times from 5 to 25 minutes. One of the strips developed to a low gamma was then intensified and after drying, the densities of the intensified strip were determined on the densitometer. An unintensified negative having a visual density contrast similar to that

of the intensified negative was selected and the two were printed side by side on motion picture positive film. The strip of positive film was then developed in the D-16 developer for an average time of development, the densities of the resulting prints read on the densitometer, and the results plotted as shown in Fig. 3.

Referring to Fig. 3, curve I_o represents the characteristic H & D curve of the negative before intensification while the curve I_v is the visual density-exposure curve of the same negative after intensification. Curve 2 is the reproduction curve obtained by printing the

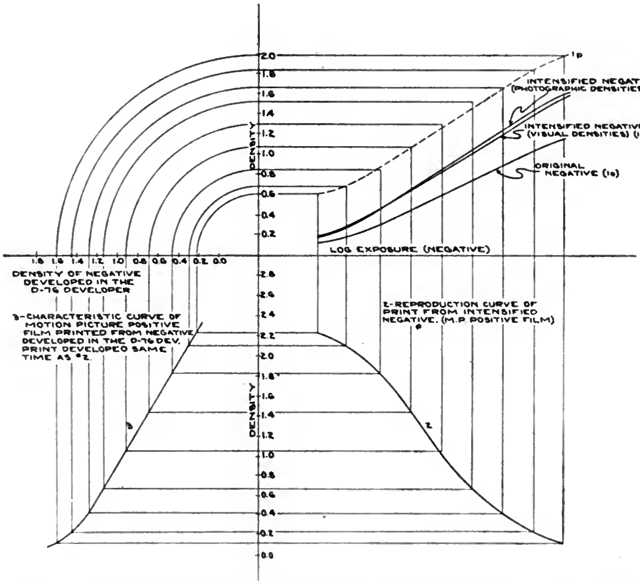


FIG. 3. Curves illustrating method of determining color coefficient.

intensified negative. The characteristic H & D curve of the positive film developed to the same gamma as the print represented by 2 is given by Curve 3. Curve I_p is the derived curve which represents the relation of the photographic densities of the intensified negative to the exposures which produced the original negative. Curve I_p when translated for comparison becomes I_p'. The data given in Fig. 3 are from the results of actual experiments using the chromium intensifier. The ratio of the gamma of I_p to that of I_v was 1.05, showing that the photographic contrast was practically identical with the visual contrast.

THE CHROMIUM INTENSIFIER

The method of intensifying with chromium[6] has long been favored in cases where a mild degree of intensification is desired. The process consists of bleaching the silver image in a mixture of chromic acid with sodium chloride or bromide or sodium or potassium bichromate with hydrochloric or hydrobromic acid, and then redeveloping the bleached image in an ordinary developer.

Chemistry of the Process.—The reactions involved have been the

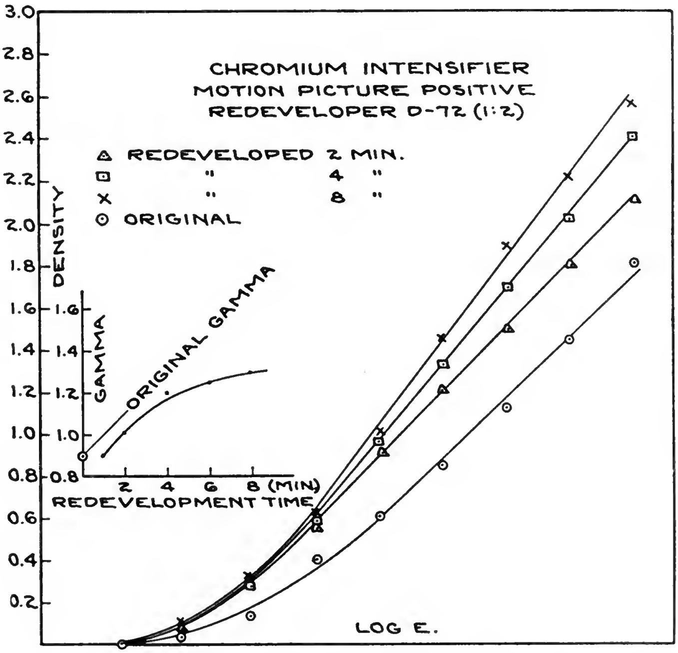


FIG. 4. Effect of chromium intensifier in increasing visual contrast of motion picture positive and panchromatic negative film.

subject of much discussion and conjecture,[7,8,9,10] but the course of the bleaching reaction is probably as follows:

$2Ag$ +	$K_2Cr_2O_7$ +	$2HCl$	= $2AgCl$	+ A Reduction product of
Silver	Potassium Bichromate	Hydrochloric Acid	Silver Chloride	the bichromate

The silver halide formed in the bleaching reaction is reduced to silver during the redevelopment which follows and a colored com-

pound of chromium (probably a lower oxide) remains in the image thus increasing the density.

Degree of Intensification.—Using motion picture panchromatic negative film developed in the D-76 borax developer to a gamma of 0.5, a single treatment in the chromium intensifier gave a visual intensification of 40 per cent for both high and low densities. The degree of intensification was controlled between limits by a variation in the time of redevelopment. Increased intensification was obtained by repeated bleaching and redevelopment.

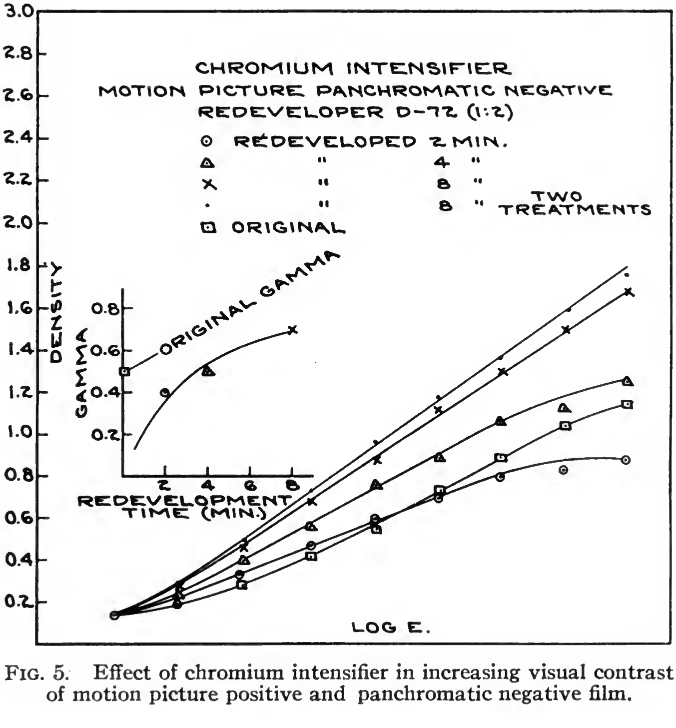


FIG. 5. Effect of chromium intensifier in increasing visual contrast of motion picture positive and panchromatic negative film.

The effect of the chromium intensifier in increasing the visual contrast of motion picture positive and panchromatic negative film is shown in Fig. 4 and Fig. 5.

Studies by Carnegie and Piper[6] of the factors affecting chromium intensification have shown that the degree of intensification can also be altered by a variation in the concentration of the hydrochloric acid constituent of the bleach bath, a lower acid content producing

a relatively higher degree of intensification. The quantity of acid cannot be decreased indefinitely, however, or a slow rate of bleaching results.

In the present investigation a minimum quantity of hydrochloric acid determined from practical considerations was found desirable. The addition of a small quantity of potassium bromide[11] (5 grams per liter) to the bleaching solution was also found to increase the rate of bleaching and produce a slightly greater degree of intensification with motion picture positive film. The increase in the rate of bleaching and the degree of intensification obtained by the addition of potassium bromide is shown in Table I. It will be noted that with motion picture negative film the addition of potassium bromide produced no significant increase in the degree of intensification. The rate of redevelopment of the films bleached in the solutions containing bromide was less than that of films bleached in the solution without bromide, thus necessitating an increased time of development.

TABLE I

Relative Degree of Intensification and Increase in the Rate of Bleaching Obtained by the Addition of Potassium Bromide to the Bleaching Solution

Nature of Film	Quantity of Potassium Bromide Added per Liter	Time for Complete Bleaching (Continuous Agitation)	Per Cent Increase in Gamma
M. P. Positive	No addition	1 minute	47
M. P. Positive	1 gram	45 seconds	..
M. P. Positive	5 grams	20 seconds	68
M. P. Positive	10 grams	10 seconds	..
M. P. Pan. Neg.	No addition	240 seconds	25
M. P. Pan. Neg.	1 gram	90 seconds	..
M. P. Pan. Neg.	5 grams	40 seconds	31
M. P. Pan. Neg.	10 grams	20 seconds	..

Color of the Intensified Image.—It has been pointed out that from the standpoint of judging negatives it is desirable to obtain an intensified image having a neutral color so that the effective photographic contrast when the negative is printed will be equal to the visual contrast. With the chromium intensified negatives redeveloped in an elon-hydroquinone developer the color coefficient or the ratio of the photographic contrast to the visual contrast over the straight line portion of the H & D curve was found to be 1.05. (See Fig. 3.) A second intensification treatment resulted in a color coefficient of 1.19.

With projection prints a single treatment with the chromium intensifier produced a 40 to 50 per cent increase in contrast. The intensified image on motion picture positive film when projected with an arc projector on an aluminum screen was observed to have a slight brown hue.

Effect of Nature of Redeveloper upon Color of Image.—The color of the chromium intensified image was found to be subject to variation depending upon the nature of the redeveloper used. With an elon-hydroquinone developer containing sodium sulfite and sodium carbonate the brown color of the intensified image became darker in hue as the alkalinity was increased. Using developers of intermediate alkalinity, the color of the intensified image changed from medium brown with high sodium sulfite content (100 grams per liter) to a much darker, almost black, color with 10 to 30 grams of sodium sulfite per liter of solution. The color of the image also became more nearly neutral when the developer contained upward of 20 per cent of elon as compared with the weight of hydroquinone using a developer formula which contained a total of 5 grams of developing agents.

Permanence of Chromium Intensified Images.—So far as is known the chromium intensified image is indefinitely permanent. The compound which is responsible for the increase in density is probably a lower oxide of chromium[7] which is unaffected by moisture or impurities in the atmosphere.

Effect of Successive Treatments.—It has already been stated that the degree of intensification can be increased by repeating the bleaching and redeveloping process. Table II shows the visual increase in low, intermediate, and high densities produced by four successive treatments of motion picture panchromatic negative film.

TABLE II

Intensification (Visual) Resulting from Successive Treatments with the Chromium Intensifier

(Eastman Motion Picture Panchromatic Negative Film)

	Low Density (Including Fog Density)	Intermediate Density	High Density
Original film (unintensified)	0.30	0.78	1.17
After 1 treatment	0.34	1.00	1.52
After 2 treatments	0.46	1.10	1.72
After 3 treatments	0.47	1.16	1.80
After 4 treatments	0.50	1.22	1.86

With an increasing number of treatments the photographic contrast increased at a greater rate than the visual contrast as has been shown above by the change of the color coefficient from 1.05 to 1.19 with one and two treatments, respectively. The use of more than two treatments is often impractical and a satisfactory degree of intensification is generally obtained with a single treatment.

Reduction of the Chromium Intensified Image.—Chromium intensified images can be conveniently reduced by treatment in a dilute acid solution. Tests made with dilute hydrochloric and sulfuric acids gave the following results.

TABLE III

Reduction of Chromium Intensified Images

Nature of Film	Density Original	Density Intensified	Treated in Dilute Hydrochloric Acid* 5 Min.	10 Min.	30 Min.	Treated in Dilute Sulfuric Acid** 5 Min.	10 Min.	30 Min.
M. P. Positive	1.58	2.38	2.14	2.10	2.02	2.12	2.08	1.78
M. P. Pan. Neg.	0.98	1.36	1.30	1.24	1.18	1.30	1.22	1.10

* Hydrochloric acid (conc.) 50 cc. per liter of solution.

** Sulfuric acid (conc.) 20 cc. per liter of solution.

The results show that either dilute hydrochloric or sulfuric acid may be employed to decrease or remove the addition product which is responsible for the intensification. Only film which has been suitably hardened with formalin prior to the chromium intensification should be treated with acids, otherwise excessive softening of the gelatin and reticulation is apt to occur.

THE MERCURY INTENSIFIER

Mercury intensification consists of depositing metallic mercury or one of its compounds on the silver image. This is effected by first bleaching the silver image in mercuric chloride according to the following equation:

$$\underset{\text{Silver}}{Ag} + \underset{\text{Mercuric Chloride}}{HgCl_2} \longrightarrow \underset{\text{Silver Mercurous Chloride}}{AgCl.HgCl}$$

The product formed, according to Chapman Jones[1,3] is known as silver mercurous chloride. In the redevelopment process which follows, this compound is reduced and a silver and mercury amalgam or various quantities of silver, mercury, and compounds containing silver and mercury are produced, depending upon the nature of the redeveloper used. With sodium sulfite some of the silver mercurous chloride is dissolved during redevelopment so that maximum in-

tensification is not obtained. Alkaline developers containing sulfite may also be used as redevelopers but they also exert a solvent action. Ammonia should be avoided because, in spite of the primary action of intensifying the image, solvent action results upon longer treatment and fine details may be lost.

The use of sodium sulfide in converting the bleached image to silver and mercury sulfides is satisfactory for the intensification of negative film if the gelatin of the film has been pre-hardened with formalin so as to prevent undue softening in the alkaline sulfide solution. The process of sulfiding, however, permits of only a single intensifying treatment. For motion picture positive film which is to be projected, the redevelopment with sulfide is not desirable because the image is slightly brown in color.

The most widely used mercury intensifier is the so-called Monckhoven's intensifier.[12] By this method the bleached image consisting of silver mercurous chloride or bromide is redeveloped by treating with a solution of potassium silver cyanide. The precise chemical reaction involved is not definitely known but the final image probably consists of silver, silver chloride or bromide, silver cyanide and mercuric cyanide.

Images bleached with mercuric chloride or bromide may also be redeveloped by the use of the ferrous oxalate developer. The intensified image is stated by Chapman Jones[3] to be permanent and to consist of the metals silver and mercury. In the processing of motion picture film the use of solutions employing the oxalates is undesirable because insoluble precipitates are produced with water containing calcium and magnesium salts.

Degree of Intensification.—The high degree of intensification possible with mercury suggests its use for title work and for purposes where a high degree of contrast is desirable. The intensification process is not subject to such precise control as is possible with the chromium intensifier but for line work close control is not essential. The increase in density produced when using motion picture positive and panchromatic negative film intensified by one treatment with the Monckhoven's intensifier is shown in Table IV.

TABLE IV

Degree of Intensification Obtained with Monckhoven's Intensifier (One Treatment)

Kind of Film	Original	Intensified	Original	Intensified	Original	Intensified
M. P. Pos.	0.10	0.18	0.96	1.67	1.58	2.95
M. P. Pan. Neg.	0.13	0.25	0.68	1.24	1.1	1.98

Color of the Intensified Image.—If the bleached image of motion picture positive film was redeveloped with an alkaline developer such as D-16 a slight brown color was observed upon projection. The average degree of intensification obtained in this case, however, was only 30 per cent as compared with 100 per cent produced with the Monckhoven formula.

Permanence of Mercury Intensified Images.—Although intensification with mercury usually produces ample increase in contrast, its use in connection with certain redeveloping solutions has been discouraged in cases where stability or permanence of the intensified image is important.

Throughout the literature many statements refer to the impermanence of mercury intensified images. Chapman Jones[1,3] states that the images resulting from the use of Monckhoven's reagent and also ammonia are liable to subsequent change but those redeveloped with ferrous oxalate are permanent.

The permanence of the image resulting when the silver-mercurous chloride image is sulfided can obviously not be questioned since the silver and mercury sulfides are relatively inert.

Reduction of the Intensified Image.—In cases where the redevelopment is effected with the Monckhoven solution the image may be reduced by treating the film in a solution of sodium thiosulfate (hypo). Table V indicates the reduction in density obtained by treating intensified motion picture positive and panchromatic negative film with a 5 per cent solution of hypo.

TABLE V

Reduction of Images Intensified with Monckhoven's Intensifier
(Treatment for 5 Minutes with 5 Per Cent Hypo Solution)

M. P. Positive Film			M. P. Panchromatic Negative Film		
Original	Intensified	Reduced	Original	Intensified	Reduced
1.88	....	2.05	1.10	1.98	1.25
1.58	2.95	1.74	0.98	1.79	1.11
1.28	2.32	1.36	0.85	1.48	0.94
0.96	1.67	1.05	0.68	1.24	0.77
0.58	1.02	0.66	0.52	0.94	0.56
0.32	0.53	0.32	0.34	0.66	0.42
0.11	0.18	0.12	0.24	0.39	0.26

The results given in Table V indicate that the densities of an image intensified with the Monckhoven's intensifier are reduced to values similar to those of the original unintensified image by treatment with the dilute hypo solution.

THE SILVER PHYSICAL INTENSIFIER

Chemistry of the Process.—Intensification with silver by the method of physical development is one of the oldest forms of intensification and has the following advantages.

(1) Ease of control of the degree of intensification, and the possibility of repeated treatments.
(2) The color of the intensified image is neutral.
(3) The intensified image is permanent.

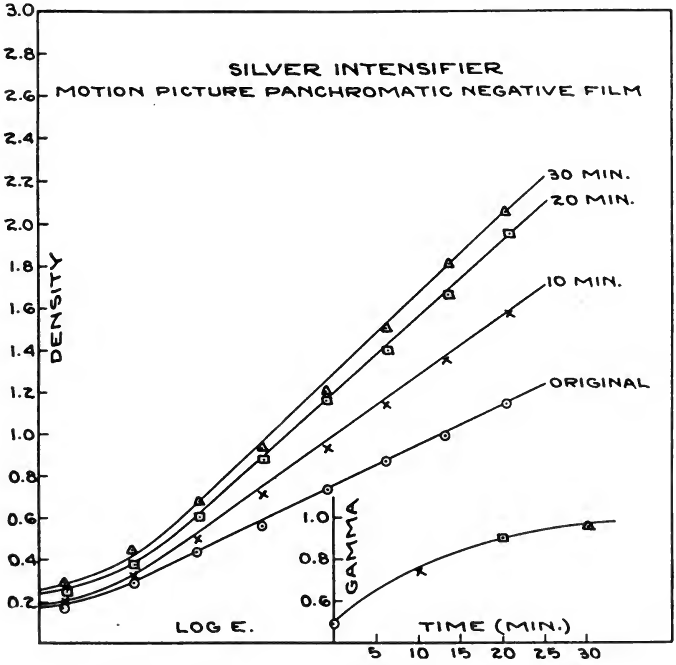


FIG. 6. Effect of increasing the time of treatment upon the degree of intensification with the silver intensifier.

Physical intensification with silver is accomplished by placing the image in an acid solution of silver nitrate containing a reducing agent such as elon in which colloidal silver is being precipitated. The silver deposits preferentially on the silver grains of the image although some is also precipitated on the walls of the vessel.

Various formulas have been proposed by Wellington,[13] Balagny,[14] Blake-Smith,[15] Von Hübl,[16] and others but these are too unstable

and work too rapidly and deposit an excess of silver on the clear portions of the image.

For effecting the chemical reduction of the silver nitrate practically all of the organic developing agents have been proposed including elon, paramidophenol, hydroquinone, pyro, and paraphenylenediamine, in acid, neutral, and slightly alkaline solutions. Complex silver salts have also been used including compounds of the thiocyanates and thiosulfates.

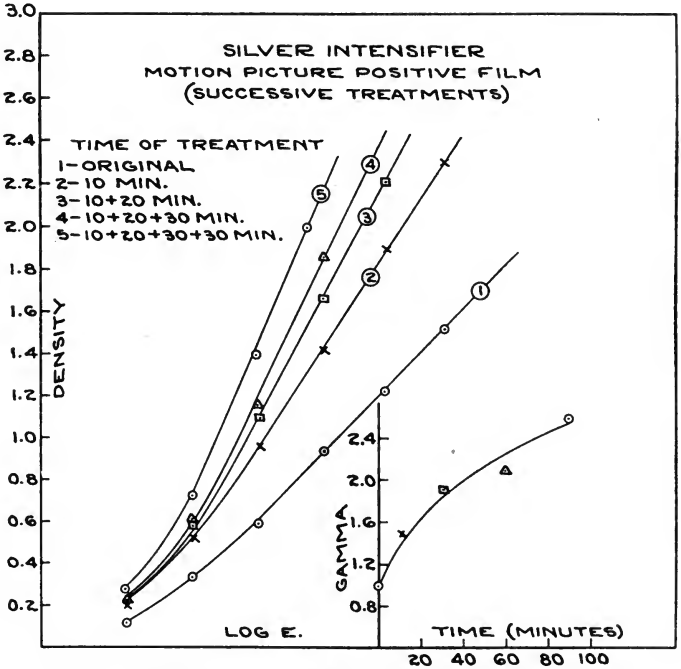


FIG. 7. Effect of increasing the time of treatment upon the degree of intensification with the silver intensifier.

Degree of Intensification.—A very stable formula employing elon, sodium sulfite, silver nitrate and hypo has been worked out for the intensification of motion picture positive and panchromatic negative film. Examples showing the effect of increasing the time of treatment upon the degree of intensification are given in Fig. 6 and Fig. 7 where the increase in contrast as measured by gamma is 90 per cent after treating with the intensifier for 30 minutes.

The nature of the intensification produced with motion picture

positive and motion picture panchromatic negative film was found to be proportional or nearly so.

Color of the Intensified Image.—When viewed by transmitted light (either daylight or arc) the image was neutral in color, that is, the color coefficient was unity. So far as is known, this process is the only one capable of intensifying the silver image on positive film without changing the color of the projected image.

Since the intensified image consists of metallic silver it is probable that the intensified image is as permanent as the original silver image itself.

Stability of the Intensifier Solution.—Many of the solutions which have been proposed and used for physical intensification with silver are quite unstable and silver is precipitated out of the solution in the form of a fine suspension which may settle out on the surface of the gelatin film and thus give rise to undesirable fog in the unexposed areas.

For the purpose of intensifying motion picture film a formula has been compounded which is reasonably stable and permits of intensification in any degree up to 90 per cent without incipient precipitation of silver from the solution. A suitable formula is given under the section entitled "Practical Recommendations."

Effect of Successive Treatments.—A high degree of intensification may be accomplished by repeated treatments. In the case of motion picture positive film a total degree of intensification of 140 per cent was obtained after a succession of separate treatments for 10, 20, 30, and 30 minutes, respectively, as shown in Fig. 7. Fresh solutions were used for each 30-minute period of treatment.

Reduction of Silver Intensified Images.—Reduction can be accomplished by the use of subtractive reducers such as the Farmer and Belitzski solutions but these do not affect the contrast of the image. In order to reduce the contrast of the intensified image a reducer which gives proportional reduction with developed silver images must be used but to date no formula has been found which gives a proportional effect with the silver intensified image.

MISCELLANEOUS METHODS OF INTENSIFICATION

The photographic properties of 20 various intensifiers have been investigated by Nietz and Huse.[5] Treatments involving the use of mercuric and cupric salts, lead and uranium ferricyanides, potassium bichromate with hydrochloric acid followed by redevelopment and

physical development with an acid silver intensifying solution were considered. Of these methods, those suitable for motion picture film employing mercury, chromium, and silver have already been described in this paper.

Toning methods in which inorganic compounds such as uranium, copper, or vanadium ferrocyanides are deposited on the image may be used for intensifying very faint negative images although with these intensifiers the visual appearance of the intensified negative is not a direct measure of the effective printing density and the images are not stable since the silver ferrocyanide is readily attacked by the hydrogen sulfide in the air forming silver sulfide. Nietz[5] found that with the uranium intensifier an extremely high degree of intensification (200 per cent added) was produced.

The color of the uranium intensified image varies from red to brown, depending upon the relative proportions of silver and uranium ferrocyanides present in the image.

A satisfactory degree of intensification may also be obtained by mordanting basic dyes to the silver image by any of the well-known dye mordanting methods.[17]

A medium degree of intensification with negatives is produced by converting the silver of the image to brown silver sulfide. The process is usually accomplished by bleaching the negative in a solution of potassium ferricyanide and potassium bromide, washing, and sulfiding in a 1 per cent solution of ammonium or sodium sulfide. The gelatin is generally softened by the alkaline sulfide solution unless precautions have been taken previously to harden the film with formalin. This method has the disadvantage that only one degree of intensification is possible.

Wilsey[18] has described methods of intensification which utilize the staining property of pyro to produce a brown stain image *in situ* during the redevelopment of a silver halide image. The negatives are bleached in either a solution of (1) potassium ferricyanide-potassium bromide, or (2) potassium permanganate, sodium chloride, and sulfuric acid, washed, and fully redeveloped with a pyro developer having a low sodium sulfite concentration. The degree of intensification possible with a single treatment is dependent upon the concentration of sulfite in the developer, a low content giving the greatest amount of stain. Unfortunately, with this method the developing solution rapidly changes in composition due to aerial oxidation and precise control is not possible. Stains may also be produced in the

non-image portions if the film wetted with developer is allowed to remain in contact with the air for an appreciable time.

A useful single solution mercury intensifier[19] consists essentially of complex ammonium or potassium mercuric sulfocyanide. The resulting image may be rendered permanent by treating with sodium sulfide or redeveloping with ferrous oxalate.

A simple method of intensification consists of making a duplicate copy with a higher density scale than that of the original. Methods of making duplicate negatives have been described by Capstaff and Seymour[20] and Ives and Huse.[21]

Color Coefficients of Intensifiers.—The relative color coefficients or the ratio of the photographic contrast (gamma) to the visual contrast over the straight line portion of the characteristic curve have been determined for the chromium, mercury, and silver intensifiers as follows:

Intensifier	Nature of Film	Color Coefficient
Chromium (1 treatment)	M. P. Panchromatic	
(D-72 redeveloper, 1:2)	Negative	1.05
Chromium (2 treatments)	M. P. Panchromatic	
(D-72 redeveloper, 1:2)	Negative	1.19
Mercury (D-16 redeveloper)	M. P. Pan. Neg.	1.01
Silver	M. P. Pan. Neg.	1.00
Chromium (1 treatment)	M. P. Positive	1.04
(D-72 redeveloper)		
Mercury (Monckhoven's)	M. P. Positive	1.08
Mercury (D-16 redeveloper)	M. P. Positive	0.93
Silver	M. P. Positive	1.00

The color coefficients given above are based upon an assumed color coefficient of unity for the motion picture panchromatic negative film developed to a relatively low gamma (0.5) in the D-76 borax developer, and an assumed color coefficient of unity for the motion picture positive film developed to a relatively low gamma (1.0) in the D-16 developer.

The color coefficients were determined in a manner similar to that described under the heading "The Chromium Intensifier," and the motion picture positive film used for intensifying was developed in the D-16 developer.

From the above data, for practical purposes, the color coefficients of the intensifiers can be assumed to be unity except in the case of two treatments in the chromium intensifier where a color coefficient of 1.19 was obtained.

PHOTOGRAPHIC REDUCERS

In the strict sense of the word, a photographic reducer is a medium which diminishes the effective density of any photographic deposit but generally speaking, the term "photographic reduction" is used to designate the removal of more or less of the metallic silver from a silver photographic image.

The object of reduction may be to (*a*) diminish the average density of the image so as to decrease the printing time, (*b*) lower the density scale of a negative picture image, (*c*) correct for overexposure or overdevelopment of a positive image, and (*d*) remove traces of fog.

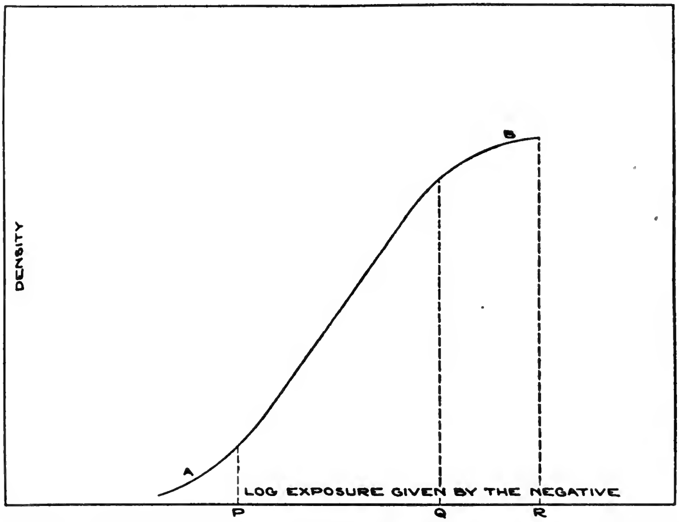


FIG. 8. H & D curve of positive film, used in discussing reduction.

Referring to Fig. 8, if AB is the characteristic curve of a motion picture positive emulsion developed to any gamma, then if the density scale of the negative is such that the exposure scale given in printing is equal to PR (log E units) it is not possible to reproduce all the tones of the negative on the straight line portion of the characteristic curve of the positive emulsion. In order to do this, it is necessary to reduce the density scale of the negative so that the exposure scale is correspondingly reduced from a value of PR to a value of PQ.

Chemical Nature of Photographic Reducers.—Photographic reducers depend upon the properties of chemical oxidizing solutions to

convert the silver of the image to a silver compound which is (*a*) soluble in water or an acid solution, or (*b*) relatively insoluble and can be dissolved easily by the use of hypo or other solvents.

Types of Reducers.—A reducer may decrease the image density in one of three ways, as follows:

(1) By removal of equal density increments from the high, intermediate, and low densities, respectively. Such reducers are known as "subtractive" or "cutting" reducers.

(2) By removal of density in amount which is proportional to the original density. These are termed "proportional" reducers.

(3) By removal of density increments which bear a greater proportion to the original density as the magnitude of the original density increases. These are termed "super-proportional" reducers. Such reducers have also been called "flattening" reducers but such a term leads to confusion with proportional reducers which also decrease contrast.

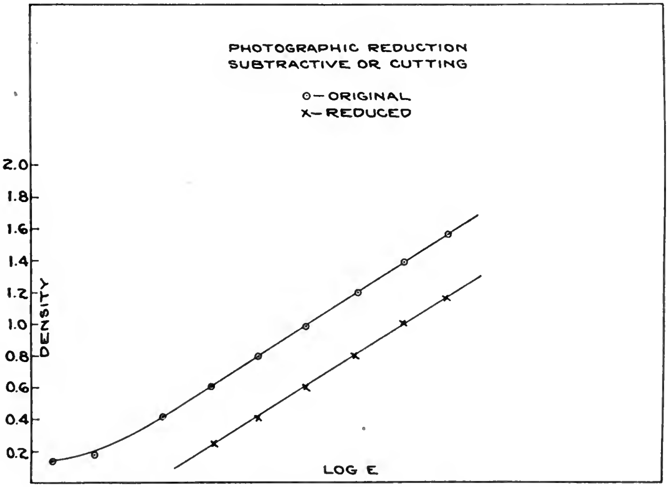


FIG. 9. Effect of subtractive or cutting reduction.

The nomenclature of Luther[22] has been adopted with the exception of the term "sub-proportional." From the results obtained in this investigation and a review of published data on the subject it would appear that other categories are necessary to completely classify the types of reduction not included under the designations—subtractive, proportional, and super-proportional.

The results obtained with each of the above types of reducer are shown diagrammatically in Figs. 9, 10, and 11.

Of the various types, the subtractive and proportional reducers are probably the most important because they do not distort the straight line portion of the characteristic curve, whereas with a super-proportional reducer the straight line is bent toward the log E axis.

Method of Measurement.—The properties of the photographic reducers were determined as follows:

(1) The densities of a suitable sensitometric step density strip were determined and a characteristic H & D curve plotted.
(2) The sensitometric film strip was reduced, the densities of the reduced image determined, and the H & D curve plotted.
(3) The relation between the visual and photographic characteristics of the images before and after reduction was determined.

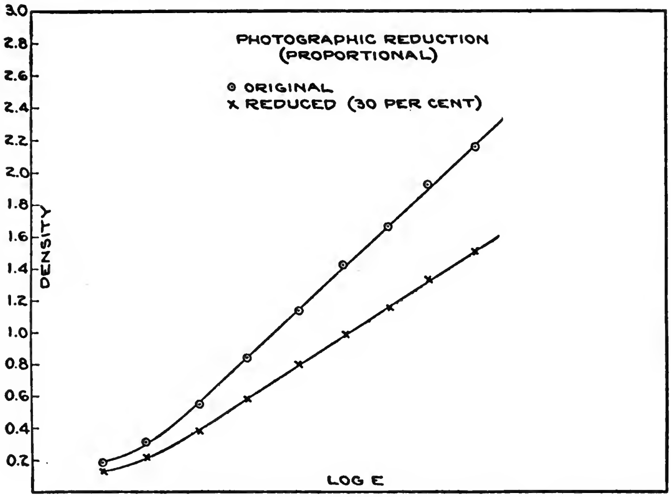


FIG. 10. Effect of proportional reduction.

The sensitometric strips used in the test were printed on both motion picture positive and motion picture panchromatic negative film on a continuous motion picture printer, using a looped negative consisting of matched step tablets (each 1 foot in length). Two hundred-foot lengths of motion picture positive and motion picture panchromatic negative film were printed and developed to high degrees of contrast in the D-16 and D-76 developing solutions, respectively.

The reduction tests were carried out in trays which were continuously rocked during the treatment and strips of the positive and negative film were treated for increasing times in the various reducing

solutions. The density readings of the sensitometric strips before and after reduction were made by the use of the Capstaff densitometer.

Following the sensitometric tests and as a further check on the properties of those reducers which appeared promising, lengths of developed motion picture positive and panchromatic negative film were reduced by the usual methods of processing.

Properties of Reducers Suitable for Motion Picture Work.—The requirements of a photographic reducer for the treatment of motion picture film are similar to those for the reduction of other photographic materials as follows:

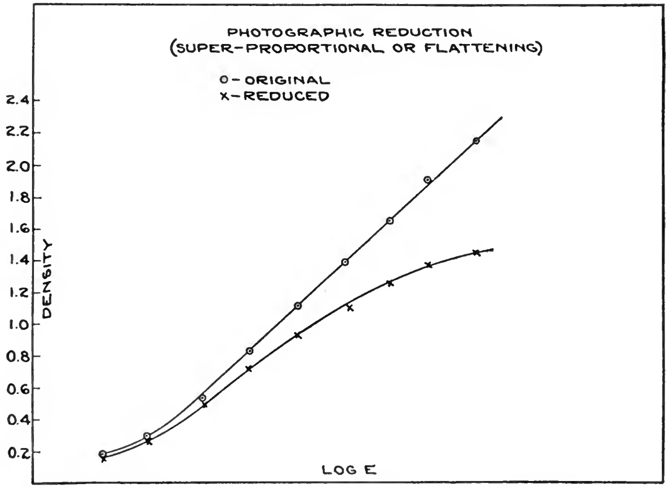


FIG. 11. Effect of super-proportional or flattening reduction.

(1) The solution should be reasonably stable.
(2) The reduction process should be capable of easy control so that varying degrees of reduction can be obtained.
(3) The reduction process should not change the color of the original image.
(4) The image after reduction should be stable.
(5) The solution should have no deleterious effect on the gelatin or the film support and should be relatively non-toxic.

With these requirements as criteria, a survey was made of published reducer formulas and their specific effects and those reducers which appeared promising for use in motion picture work were then investigated.

SUBTRACTIVE REDUCERS

1. *Farmer's Reducer.*—A widely used formula is that proposed by Howard Farmer[23] which consists of a mixture of potassium ferricyanide and hypo. The chemical reactions involved may be represented by the following equations:

(*a*)	$4Ag$	$+ 4K_3Fe(CN)_6$	$= Ag_4Fe(CN)_6$	$+ 3K_4Fe(CN)_6$
	Silver	Potassium Ferricyanide	Silver Ferrocyanide	Potassium Ferrocyanide

(*b*)	$3Ag_4Fe(CN)_6$	$+ 16Na_2S_2O_3$	$= 4Na_5Ag_3(S_2O_3)_4$	$+ 3Na_4Fe(CN)_6$
	Silver Ferrocyanide	Hypo	Sodium Silver Thiosulfate	Sodium Ferrocyanide

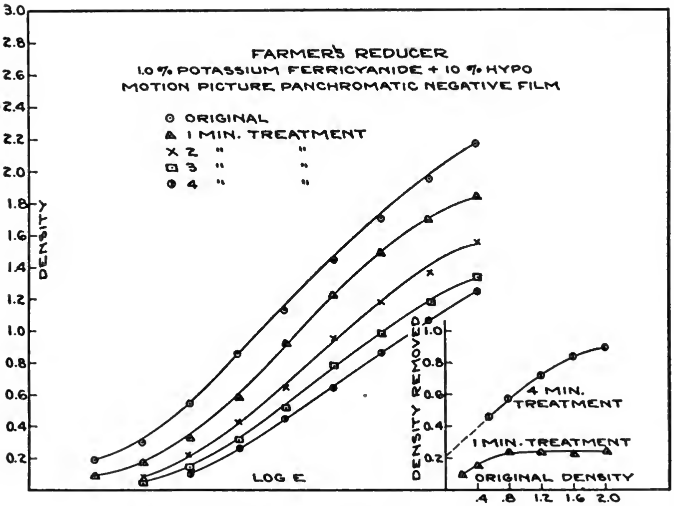


FIG. 12. Effect of a vigorously acting solution, showing subtractive properties.

The silver image is attacked and oxidized by the ferricyanide, and insoluble silver ferrocyanide formed but this is readily dissolved by the hypo. The reaction continues somewhat after removal of the film to the wash water and due allowance should be made for this.

Nature of the Reduction.—Although Farmer's reducer has long been classed as a "subtractive" or "cutting" reducer, the type of the effect obtained depends to a great extent upon the nature of the image which is being reduced and upon the composition of the reducing solution. With a vigorously acting solution such as one containing 1 per cent of potassium ferricyanide and 10 per cent sodium thiosulfate the

effect was found to resemble closely that of a pure subtractive reducer with both motion picture positive film and motion picture panchromatic negative film. (Fig. 12.)

With motion picture positive film the action of a solution containing a low concentration of the ferricyanide (0.4 per cent) was subtractive. With concentrations of ferricyanide less than 0.5 per cent or concentrations of hypo less than 5 per cent the effect with motion picture negative film was such that the contrast was decreased, indicating the removal of less silver from the lower than from the higher densities with a tendency toward proportional reduction. This

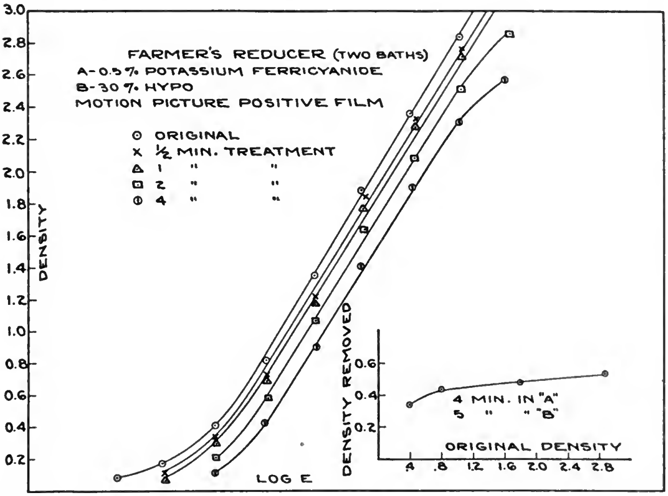


FIG. 13. Typical curves, showing behavior of two-solution reducer.

effect was less marked with motion picture positive film and a nearly subtractive effect was obtained in all cases.

The difference between the behavior of the negative and positive film images was undoubtedly a result of the difference in the grain size-distribution characteristics of the two films, bearing in mind that the smaller grains are more easily attacked or dissolved than the larger ones. The tendency of Farmer's reducer to produce lower contrasts under certain conditions and therefore give proportional reduction has been observed by Stürenburg,[24] Scheffer,[25] Stenger and Heller,[26] Piper,[27] Renwick,[28] and Baker.[29]

Color of the Reduced Image.—If a relatively large proportion of the image on motion picture positive film is removed by Farmer's re-

ducer, a slight brown stain may be observed in the reduced image. This stain which was found to be less prevalent with film fixed in a fixing bath used for the fixation of negative film probably consists of silver sulfide which is apparently produced during the reduction process.

The stain did not appear to an appreciable extent with negative film and the quantity produced with positive film for medium degrees of reduction was negligible. It was found that if after development the positive film was fixed in a fixing bath containing from 0.1

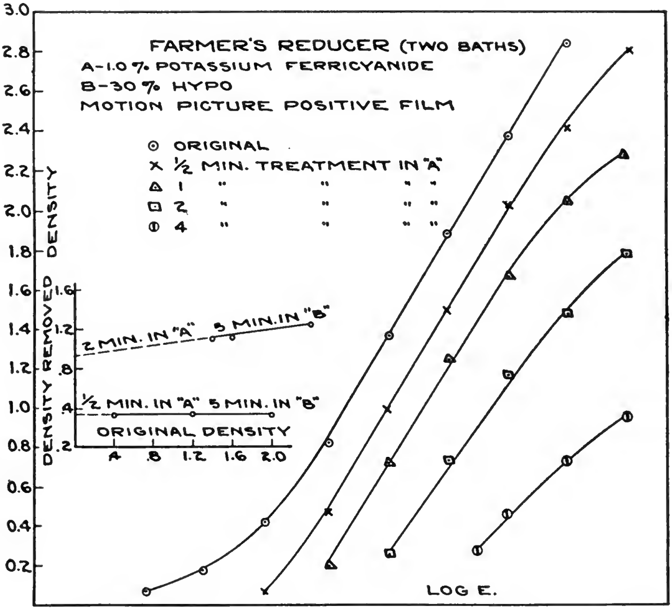


FIG. 14. Typical curves, showing behavior of two-solution reducer.

to 1.0 per cent potassium iodide, no stain was obtained on reduction. The nature of this effect will be dealt with in a later communication.

Stability of the Solutions.—On standing, the reducing properties of the solution are rapidly destroyed due to reduction of the ferricyanide by the hypo. It is therefore necessary to prepare the solution immediately before use.

The stability of the solution can be increased by the addition of 10 cc. of ammonia or 10 grams of sodium carbonate (desiccated) per liter as shown in Table VI.

TABLE VI

Keeping Life of Farmer's Reducer with the Addition of Ammonia

Composition of the Reducer Solution (*Grams or Cc. per Liter*)			
Potassium Ferricyanide	Sodium Thiosulfate	Ammonia (28 Per Cent)	Keeping Life
3.75 grams	12.5 grams	No addition	8 hrs.
3.75 grams	12.5 grams	10 cc.	48 hrs.
3.75 grams	12.5 grams	20 cc.	48 hrs.
3.75 grams	12.5 grams	40 cc.	48 hrs.

Keeping Life of Farmer's Reducer with the Addition of Sodium Carbonate

Composition of the Reducer Solution
(*Grams per Liter*)

Potassium Ferricyanide	Sodium Thiosulfate	Sodium Carbonate (Desiccated)	Keeping Life
3.75 grams	12.5 grams	No addition	8 hrs.
3.75 grams	12.5 grams	1 gram	12 hrs.
3.75 grams	12.5 grams	5 grams	24 hrs.
3.75 grams	12.5 grams	10 grams	48 hrs.

A much more satisfactory method of reducing with ferricyanide and hypo is to employ them as two separate solutions. The film is first immersed in the ferricyanide and then transferred to the hypo solution. Increasing the time of bathing increases the quantity of silver ferrocyanide formed which, in turn, increases the degree of reduction when the film is transferred to the hypo solution. The following table indicates the limits of useful concentrations of the ferricyanide for motion picture positive and negative films.

TABLE VII

Effect upon the Degree of Reduction of Variations in the Concentration of Potassium Ferricyanide in the First Stage of the Two-Solution Farmer's Reducer

Film	Concentration of Potassium Ferricyanide (*Grams per Liter*)	Density Removed* from a Density of 0.5	1.0	2.0	2.8
M. P. Panchromatic Negative	7.5	0.1	0.18	0.35	...
M. P. Panchromatic Negative	15.0	0.28	0.5	0.8	...
M. P. Positive	5.0	0.3	0.4	0.5	0.5
M. P. Positive	10.0	....	....	1.8	2.1

* Treated in the ferricyanide solution for 4 minutes.

These data indicate the desirability of using a concentration of 5 to 7.5 grams of potassium ferricyanide per liter for treatment of the positive film and not less than 7.5 grams per liter for the panchro-

matic negative film. The absolute time of treatment in this solution depends somewhat upon the degree of agitation of the solution. The concentration of sodium thiosulfate used in the second solution is not critical and may range from 50 to 300 grams per liter.

The results given in Table VII indicate an almost true subtractive action with motion picture positive film. With motion picture panchromatic negative film the type of reduction was more nearly proportional although a slight reduction of the lowest densities was obtained. Typical H & D curves showing the behavior of the two-solution reducer using various concentrations of potassium ferricyanide

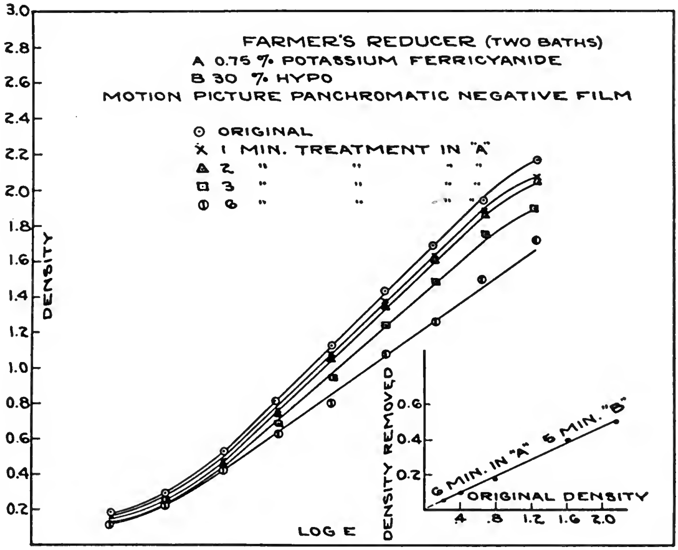


FIG. 15. Typical curves showing behavior of two-solution reducer.

with the positive and negative film are shown in Figs. 13, 14, 15, and 16.

If sufficient reduction is not obtained with one treatment in the two baths, the process may be repeated. The film to be further reduced may be washed slightly before re-immersion in the ferricyanide solution or if the progress of reduction is carefully observed the film may be treated without washing. The type of reduction obtained with motion picture panchromatic negative film by the use of two successive treatments (without intermediate washing) is only approximately subtractive.

2. *Haddon's Reducer.*—A single solution reducer of the subtractive type proposed by Haddon[30] consists of a mixture of potassium ferricyanide and ammonium sulfocyanide. The ferricyanide oxidizes the silver and the silver ferrocyanide formed dissolves in the sulfocyanide according to the following reaction:

$$Ag_4Fe(CN)_6 + (X + 4)NH_4CNS = XNH_4CNS.4AgCNS + (NH_4)_4Fe(CN)_6$$

Silver Ferrocyanide	Ammonium Sulfocyanide	Ammonium Silver Sulfocyanide	Ammonium Ferrocyanide

The following formula was used in the tests:

Potassium ferricyanide	5 grams
Ammonium sulfocyanide	10 grams
Water to make	1 liter

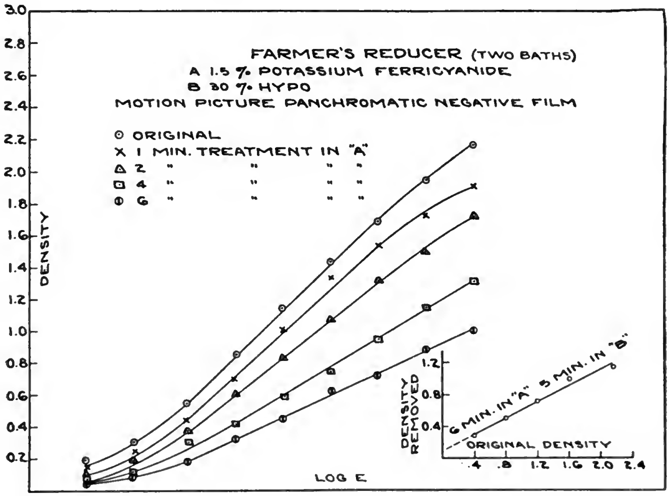


FIG. 16. Typical curves, showing behavior of two-solution reducer.

Color of Reduced Image.—The behavior of the above solution was similar to that of the single solution ferricyanide-hypo reducer but had the disadvantage that a slight quantity of a white compound, apparently silver sulfocyanide, was deposited on the surface of the film. An increase in the concentration of the sulfocyanide produced no appreciable effect upon the tendency of the white precipitate to form. The white compound was readily soluble in hypo and sodium cyanide solutions and the addition of sodium cyanide prevented its

appearance. The properties of the resulting triple cyanide reducer are given later in this paper.

Stability of the Solution.—The ferricyanide-sulfocyanide reducer was much more stable than the ferricyanide-hypo solution. In an exhaustion test the solution continued to reduce images over a period of 5 days during which time 200 feet of negative film were treated. The average life of the Farmer's reducer is less than 24 hours unless the solution is modified by the addition of ammonia or sodium carbonate as described.

3. Iodine-Cyanide Reducer.—This reducer consists of a dilute solution of the highly toxic sodium or potassium cyanide containing a small percentage of iodine. During reduction the silver is oxidized by the iodine-cyanide solution to give soluble sodium silver cyanide as follows:

$2Ag$	+	I_2	+	$4KCN$	=	$2KAg(CN)_2$	+	$2KI$
Silver		Iodine		Potassium Cyanide		Potassium Silver Cyanide		Potassium Iodide

Nature of the Reduction.—The results obtained by treating motion picture positive and panchromatic negative film for 10 minutes with the following iodine-cyanide solution are shown in Fig. 17.

Iodine-Cyanide Reducer

Sodium cyanide	5 grams
Iodine (crystals)	1 gram
Water to make	1 liter

Its behavior was similar to that of a subtractive reducer but a slightly greater quantity of silver was removed from the densest portions than from those of lower density. The mixed reducing solution rapidly loses its reducing properties on standing even without use and should therefore be prepared immediately before using.

4. Ferricyanide and Cyanide.—Of the various solvents of silver ferrocyanide, namely, alkaline thiosulfates, sulfocyanides, and cyanides, the latter are least susceptible to oxidation and a mixture of ferricyanide and potassium cyanide constitutes a very stable subtractive reducer. A suitable formula is as follows:

Potassium ferricyanide	2.5 grams
Sodium cyanide	2.5 grams
Water to make	1 liter

The solution tended to soften the gelatin during treatment so that a preliminary hardening treatment with formalin was necessary. The reducer was found to keep well without use. It was also possible to reduce a total of 200 feet of motion picture negative film per gallon during a period of 5 days. A more rapid rate of reduction was obtained by doubling the concentration of the ingredients.

A modification of the Haddon reducer was also tested which contained sodium cyanide as follows:

Potassium ferricyanide	2.5 grams
Ammonium sulfocyanide	2.5 grams
Sodium cyanide	2.5 grams
Water to make	1 liter

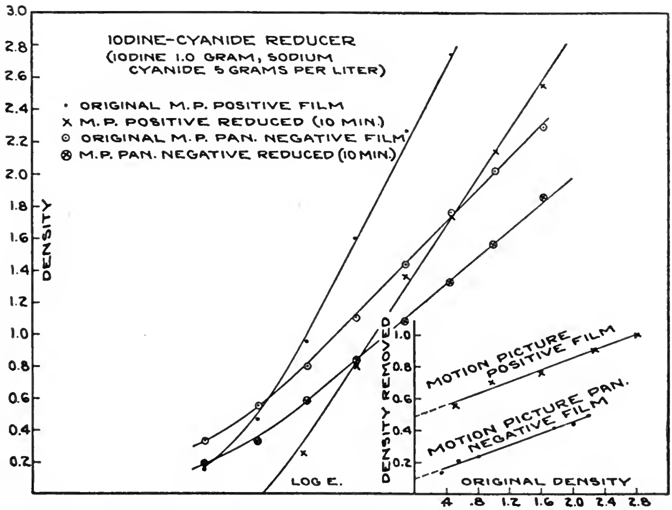


FIG. 17. Results obtained by treatment with iodine-cyanide solution.

The nature of the reduction was similar to that of the previous ferricyanide-cyanide formula and possessed no apparent advantage. Approximately 150 feet of motion picture negative film were successfully reduced per gallon of the solution and the reducing properties of the solution were maintained during a period of 3 days. The extremely poisonous nature of the cyanides has been indicated. It was also necessary to harden the gelatin of the films with formalin in order to prevent softening during treatment.

5. *A Modified Belitzski Reducer.*—Certain reducers may be classified as falling between pure subtractive and proportional reducers.

With these solutions the contrast or slope of the characteristic H & D curve was decreased as density was removed from the high and low densities but a greater proportion of silver was removed from the low densities. The reducer suggested by Belitzski[31] was found to be of this intermediate type and consists of a mixture of ferric chloride (oxidizing agent) together with sodium thiosulfate, sodium sulfite, sodium oxalate, and oxalic acid.

An objection to the use of oxalic acid or its salts is the property

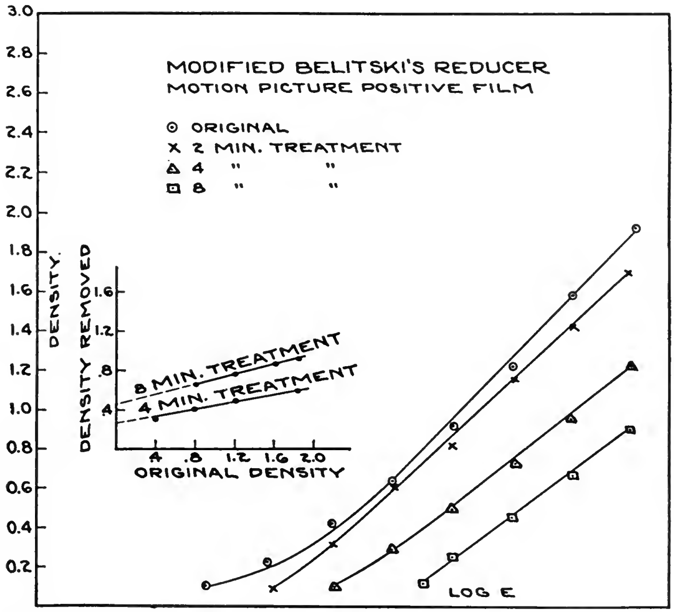


FIG. 18. Degree and type of reduction obtained with modified Belitzski reducer.

of the oxalates of reacting with the calcium and magnesium salts present in certain samples of water to give insoluble white precipitates which tend to deposit on the film.

It was found, however, that the oxalic acid and the sodium oxalate could be satisfactorily replaced by citric acid and potassium citrate. Since calcium and magnesium citrates are soluble in water no precipitation with hard water would occur. The following formula was suitable for the reduction of either motion picture positive or panchromatic negative film.

Ferric chloride (crystals)	25 grams
Potassium citrate	75 grams
Sodium sulfite (desiccated)	30 grams
Citric acid	20 grams
Sodium thiosulfate (crystals)	200 grams
Water to make	1 liter

The degree and type of reduction obtained with this reducer is shown in Fig. 18 and Fig. 19. The solution remained active for 3–5 days in a deep tank and the equivalent of 150 feet of motion picture panchromatic negative film was satisfactorily reduced per gallon.

6. *Potassium Permanganate.*—A dilute solution of potassium permanganate acidified with sulfuric acid dissolves the silver image as a result of oxidation of the silver to silver sulfate according to the following reaction:

$$10Ag + 2KMnO_4 + 8H_2SO_4 = 5Ag_2SO_4 + 2MnSO_4 + 8H_2O$$

Silver	Potassium Permanganate	Sulfuric Acid	Silver Sulfate	Manganese Sulfate	Water

The solution, however, is not stable in contact with the air for more than a few hours and some of the permanganate becomes reduced to a brown precipitate of manganese dioxide. The following is one of many suitable formulas.

Potassium permanganate	1 gram
Sulfuric acid (concentrated)	5 cc.
Water to make	1 liter

After reduction the film should be immersed for a few minutes in a solution of 1 per cent sodium bisulfite and then thoroughly washed. The behavior of the above formula is that of a subtractive reducer.

A decrease in the quantity of sulfuric acid or the use of a weak acid like acetic reduces the rate of reduction and the solution tends to give a proportional type of action.[32, 33, 34] Neutral solutions of potassium permanganate give almost proportional reduction but the action is very slow.

7. *The Bichromate Reducer.*—A solution of potassium bichromate acidified with sulfuric acid attacks the silver image changing it to silver chromate and silver sulfate.

The following formulas were tested using motion picture positive and panchromatic negative film.

	A	*B*	*C*
Potassium dichromate	1 gram	2.5 grams	5 grams
Sulfuric acid (concentrated)	1 cc.	2.5 cc.	5 cc.
Water to make	1 liter	1 liter	1 liter

The type of reduction was subtractive but a very undesirable residual stain was produced. The stain was decreased but not entirely removed by treating the films in acid hypo. Solutions *B* and *C* were so rapid in action as to be only suitable for the negative film but solution *A* gave sufficiently rapid action with the positive film.

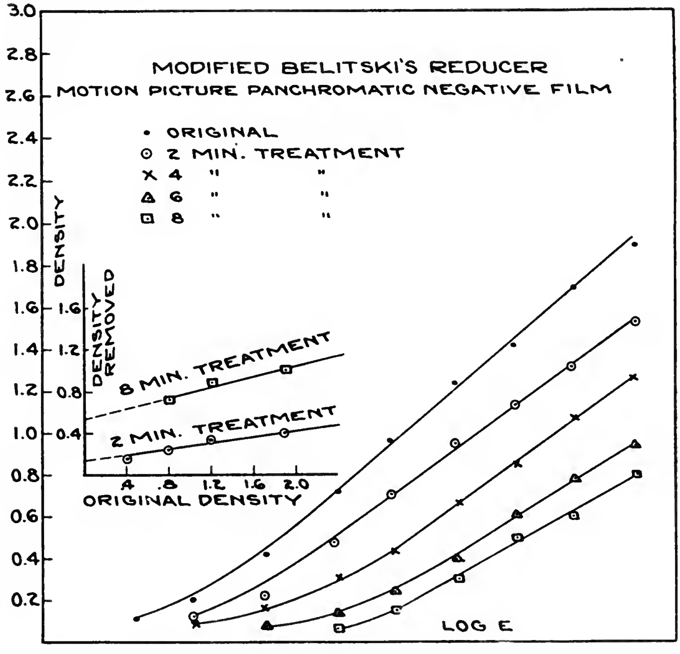


FIG. 19. Degree and type of reduction obtained with modified Belitzski reducer.

8. *Ceric Ammonium Nitrate.*—A solution containing 20 grams of ceric ammonium nitrate[35] per liter was found to give rapid reduction with motion picture negative film but on standing, a precipitate of the basic nitrate settled out of the solution in spite of the fact that the sample of ceric salt used contained an appreciable quantity of free nitric acid. Further additions of nitric acid to the reducer for the purpose of keeping the cerium salt in solution resulted in excessive softening of the gelatin.

9. *Ceric Ammonium Sulfate Reducer.*—The use of ceric sulfate as a reducer has been suggested by Lumière and Seyewetz.[35, 42] With the formula given below a type of reduction intermediate between subtractive and proportional was obtained when using motion picture positive and motion picture panchromatic negative film.

Ceric ammonium sulfate	15 grams
Sulfuric acid	10 cc.
Water to make	1 liter

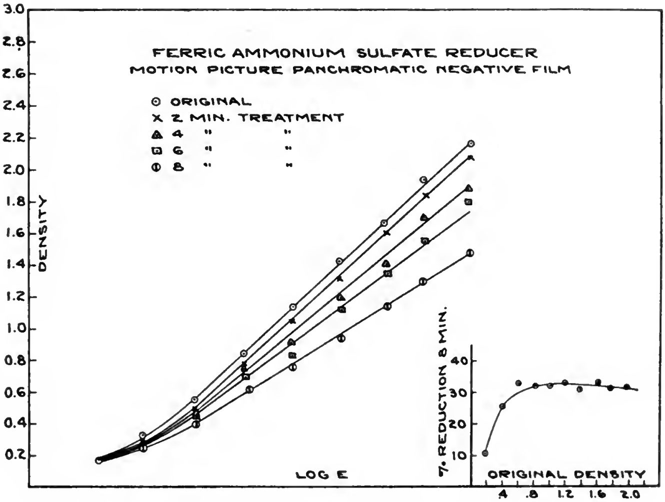


FIG. 20. Degree and type of reduction obtained with ferric ammonium sulfate reducer.

Pre-hardening of the gelatin with formalin was necessary due to the softening action of the sulfuric acid. Objectionable basic cerium compounds were precipitated from the solution on standing.

PROPORTIONAL REDUCERS

A proportional reducer employing ammonium persulfate, potassium permanganate and a small quantity of sulfuric acid has been proposed by Huse and Nietz[36] (modification of a formula by Deck). The reducer, although giving proportional action, did not have sufficiently good keeping properties to permit its use in motion picture work.

Other formulas for proportional reducers have been proposed by Lumière and Seyewetz,[37] Steigman,[38] Gehrling (according to Luther),[39] Krauss,[40] and Strauss.[41] Lumière and Seyewetz used quinone or quinone sulfonates with sulfuric acid but such solutions are brown in color and tend to stain the gelatin. Steigman has claimed that an 0.5 per cent solution of mercuric nitrate acidified with nitric acid gives proportional reduction. The use of nitric acid is, however, not to be recommended with motion picture film. Gehrling, Krauss, and Strauss have suggested the use of dilute acidi-

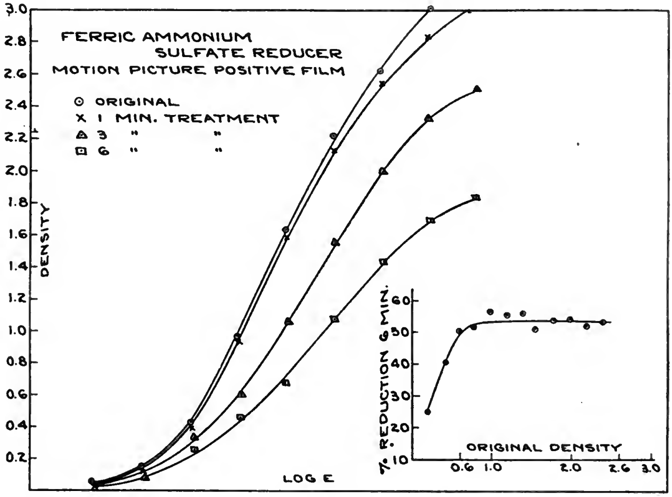


FIG. 21. Degree and type of reduction obtained with ferric ammonium sulfate solution.

fied solutions of ferric salts as giving practically proportional reduction. The reaction involved is as follows:

2Ag	+ $Fe_2(SO_4)_3 \cdot (NH_4)_2SO_4$	= Ag_2SO_4	+ $FeSO_4$	+ $FeSO_4 \cdot (NH_4)_2SO_4$
Silver	Ferric Ammonium Sulfate	Silver Sulfate	Ferrous Sulfate	Ferrous Ammonium Sulfate

The formula given by Krauss is:

Ferric ammonium sulfate	20 grams
Sulfuric acid (concentrated)	10 cc.
Water to make	1 liter

A modification of this formula, using 15 grams of the ferric salt, was tested, using both motion picture panchromatic negative and motion picture positive films. The degree and type of reduction obtained with the modified solution is shown in Fig. 20 and Fig. 21. Values of the density reduction obtained, together with the calculated percentage reduction based on the corresponding values of the original densities are given in Tables VIII and IX.

TABLE VIII

Reduction of Motion Picture Positive Film with Ferric Ammonium Sulfate

Original Density	Density after 6 Minutes	Density Reduction	Percentage Density Reduction
2.8	1.56	1.24	44
2.6	1.40	1.20	48
2.4	1.22	1.18	53
2.2	1.08	1.12	51
2.0	0.94	1.06	53
1.8	0.84	0.96	53
1.6	0.70	0.90	50
1.4	0.62	0.78	56
1.2	0.54	0.66	51
1.0	0.44	0.56	56
0.8	0.38	0.42	51
0.6	0.30	0.30	50
0.4	0.24	0.16	40
0.2	0.15	0.05	25

TABLE IX

Reduction of Motion Picture Panchromatic Negative Film with the Ferric Ammonium Sulfate Reducer

Original Density	Density after 8 Minutes	Density Reduction	Percentage Density Reduction
2.0	1.36	0.64	32
1.8	1.24	0.56	31
1.6	1.08	0.52	33
1.4	0.96	0.44	31
1.2	0.80	0.40	33
1.0	0.68	0.32	32
0.8	0.54	0.26	32
0.6	0:40	0.20	33
0.4	0.30	0.10	25
0.2	0.18	0.02	10

Referring to the graphs in Fig. 20 and Fig. 21 it is seen that with motion picture panchromatic negative film the original densities greater than 0.4 to 0.5 were reduced during treatment for 8 minutes by a constant ratio of 32 per cent, but the extremely low densities were relatively unaffected. Treatment for more than 8 minutes is not desirable because the proportional reducing properties are no longer maintained and the action on the lower densities increases.

With motion picture positive film the reduction obtained during treatment for 6 minutes with densities from 0.6 to 2.4 was practically proportional with a mean value of 53 per cent of the original value except with densities greater than 2.4 and less than 0.6. The treatment of positive film for more than 6 minutes gave a subtractive action with the low densities.

General brown stain was obtained with the ferric ammonium sulfate reducer when the films contained traces of hypo and silver salts. Stains were also obtained when the film during reduction or washing was allowed to come in contact with the air for an appreciable length of time. The gelatin of the films was softened during the treatment in the acid solution and pre-hardening with formalin was necessary.

Despite these objections, negative and positive film was satisfactorily reduced when the following procedure was rigidly followed: (*a*) The film was hardened in an alkaline formalin hardener, and (*b*) fixed in a relatively fresh fixing bath followed by thorough washing, and (*c*) the film was not exposed excessively to the air during treatment.

SUPER-PROPORTIONAL REDUCERS

Alkaline persulfates[43] (generally the ammonium salt) have been used to give super-proportional reduction. The use of such compounds is characterized by erratic differences in the rate of reduction by various solutions, apparently made up in the same manner. Without attempting to go into the various theories proposed to explain the variable activity, it should be mentioned that Sheppard[44] has shown that differences in the iron content of the persulfate are responsible for varying degrees of activity, an increased iron content giving a surprising increase in the rate of reduction. Contributions to the theory of the action of persulfate reduction have been made by Marshall,[45] Stenger and Heller,[46] Schuller,[47] Lüppo-Cramer[48] and Lumière and Seyewetz.[49]

The following is one of the many formulas employed.

Persulfate Reducer (*Formula R-1*)
(*Stock Solution*)

Water	500 cc.
Ammonium persulfate	60 grams
Sulfuric acid (concentrated)	3 cc.
Water to make	1 liter

For use: Take 1 part of stock solution and two parts of water.

When reduction is complete, immerse in an acid fixing bath for a few minutes and then wash. If too rapid a rate of reduction is obtained, the solution should be diluted further.

MISCELLANEOUS METHODS OF REDUCTION

1. A method of reduction known as "harmonizing" and originally proposed by Eder[50] consists of: (1) bleaching the silver image to silver halide by means of a solution containing potassium bichromate and a soluble halide, (2) incompletely redeveloping the bleached image, and (3) removing the undeveloped silver salt with hypo.

Tests of this process were made using (*a*) the bleaching solution of the chromium intensifier with the addition of 5 grams of potassium bromide per liter and (*b*) a dilute developer composed as follows:

Elon	2 grams
Sodium sulfite (desiccated)	10 grams
Sodium carbonate (desiccated)	10 grams
Water to make	1 liter

The bleached images were developed for relatively short times, namely, 1, 2, and 4 minutes, rinsed, and immersed in an acid fixing bath for 5 minutes. The type of reduction obtained with redevelopment for 1 and 2 minutes was super-proportional for the high densities. In the case of the low densities, however, proportional intensification was obtained. The method would appear to have merit for the reduction of underexposed negatives which have been overdeveloped.

2. A modification of the method of Eder has been suggested by

Piper,[51] who used a bleaching solution consisting of potassium ferricyanide and potassium bromide.

3. Wilsey[52] has described a reducer for negatives with pyro stained images. The process consists of removing the stain by bleaching in an acid permanganate solution containing sodium chloride and redeveloping with a non-staining developer. The type of reduction obtained is proportional when the images are fully developed.

4. Silver images may be toned with inorganic compounds or dyes to give deposits which are photographically more transparent to blue light than the original densities.[53] Toned images obtained by (1) the formation of ferric ferrocyanide and (2) the mordanting of bluish basic dyes to silver ferrocyanide are more transparent to blue light than the silver deposit of the original negative.

5. A dulpicate negative may be made which has a lower density contrast than that of the original negative. Methods of making duplicate negatives have been described by Capstaff and Seymour[20] and Ives and Huse.[21]

The Acid Fixing Bath as a Photographic Reducer.—Solutions of acid sodium thiosulfate have been found to exert a definite reducing action on the photographic image. The effect at ordinary temperatures in the usual potassium alum and chrome alum fixing baths is very slight and no reduction occurs during the normal time of fixing.

The rate of reduction of the silver image depends somewhat upon the size of the image grains and fine-grained images such as those on motion picture positive film are more rapidly reduced than those on motion picture panchromatic negative film.

The rate of reduction with a given fixing bath containing 30 per cent sodium thiosulfate was found to increase with (*a*) the degree of acidity and (*b*) the temperature. The addition of 10 per cent potassium bromide appeared to have a slight effect in increasing the rate of reduction but a considerable effect was obtained by the addition of increasing quantities of potassium iodide (0.1 to 10 per cent). Concentrations of 1 and 10 per cent silver bromide dissolved in a freshly prepared fixing bath decreased the rate of reduction. With a solution containing 1 per cent of silver bromide the rate of reduction of motion picture positive film was greatly retarded and an almost proportional action was obtained. The degree of reduction obtained with motion picture positive and motion picture panchromatic negative film treated in a strongly acid fixing bath is shown in the following table.

TABLE X

*Photographic Reduction of Motion Picture Film in a Strongly Acid Fixing Bath**

Nature of Motion Picture Film	Original Density	Density after Treatment for 5 Min.	30 Min.	1 Hr.	2 Hrs.	3½ Hrs.
Positive	0.10	0.10	0.06	0.04	0.00	0.00
Panchromatic Negative	0.16	0.16	0.16	0.14	0.12	....
Positive	0.60	0.60	0.42	0.24	0.10	0.06
Panchromatic Negative	0.60	0.60	0.50	0.44	0.36	....
Positive	1.32	1.30	1.02	0.80	0.50	0.20
Panchromatic Negative	1.32	1.32	1.10	0.96	0.78	....
Positive	2.10	2.06	1.65	1.40	1.10	0.50
Panchromatic Negative	1.86	1.84	1.60	1.40	1.18	....
Positive	2.46	2.40	2.00	1.70	1.22	0.59

* Acid fixing bath containing sodium bisulfite—30 grams, potassium chrome alum—30 grams, and hypo—300 grams per liter.

It will be seen from the above data that with motion picture positive film the type of reduction is intermediate between a subtractive and a proportional action. With panchromatic negative film the reduction was almost strictly proportional, and the gamma was decreased from 0.71 to 0.45 during treatment for 2 hours.

Reduction of Fog.—Fog consists of a more or less uniform layer of silver over the entire image surface and may be a result of (*a*) chemical development of the unexposed silver halide grains, (*b*) the formation of developed silver grains produced by a uniform light exposure (light fog), or (*c*) the deposition of dichroic silver on the film either in the developer or fixing bath.

In the case of ordinary light fog and developer fog it is not possible to remove this without removing some of the silver image also, although if the image received a generous exposure in the first place the fog can be removed without destroying the shadow detail.

Subtractive reducers are the most satisfactory for the removal of fog and these include (*a*) iodine-cyanide, (*b*) dilute acid permanganate, and (*c*) Farmer's Reducer (single solution).

For the removal of dichroic fog which consists of silver in a finer state of division than the image particles a reducer is suitable which preferentially acts on the finest grains and for this purpose a 0.5–1.0 per cent solution of sodium or potassium cyanide is the most satisfactory.

The insidious form of dichroic fog resulting from leaving film over night in a developer, may be removed fairly satisfactorily by treating for 5 minutes with a 0.5 per cent solution of neutral potassium per-

manganate. The film should then be washed and fixed in plain 30 per cent hypo for 5 minutes and finally cleared in a 10 per cent bisulfite solution, washed, and dried.

Effect of Temperature and Agitation on Degree of Reduction.—Tests to determine the effect of temperature on the degree of reduction were made with the two-solution Farmer's reducer, the modified Belitzski formula (diluted 1:1), and the ferric ammonium sulfate reducer using motion picture positive film. The degree of reduction obtained at temperatures of 60°, 70°, 80°, and 90°F. is shown in Table XI.

TABLE XI

Effect of Temperature on Degree of Reduction

Reducer	Temperature	Time of Treatment (Min).	Density Removed from Original Density of 0.46	1.70	2.62
2-Solution Farmer's	60°F.	'4	0.16	0.40	0.56
	70	4	0.16	0.44	0.58
	80	4	0.16	0.45	0.61
	90	4	0.16	0.48	0.78
Modified Belitzski	60	3	0.15	0.17	0.32
	70	3	0.17	0.20	0.34
	80	3	0.24	0.26	0.36
	90	3	0.38	0.40	0.51
Ferric ammonium sulfate	60	5	0.14	0.54	0.48
	70	5	0.14	0.60	0.72
	80	5	0.14	0.70	0.82
	90	5	0.14	0.82	0.86

The results indicate that over a normal range of temperature from 60°F. to 80°F. only a slight change in the rate of reduction occurs.

The effect of agitation on the rate of reduction was determined for the above-mentioned reducers using both positive and negative film. Tests were made with (*a*) no agitation of the reducing solution, (*b*) continuous agitation of the solution, and (*c*) brush treatment. An appreciable difference in the degree of reduction was obtained between (*a*) and (*b*), while only a slight difference was obtained between (*b*) and (*c*). Continuous, thorough agitation of the reducing solution in contact with the film is highly desirable.

Color Coefficients of Reducers.—The relative color coefficients* for the two-solution Farmer's reducer, the modified Belitzski formula

* The method used for the determination of the relative color coefficients was the same as that employed for intensifiers.

and the ferric ammonium sulfate reducer (see section "Practical Recommendations") were found to be as follows:

Reducer	Nature of Film	Color Coefficient
2-Solution Farmer's	M. P. Panchromatic Negative	1.07
Modified Belitzski	M. P. Panchromatic Negative	1.03
Ferric ammonium sulfate	M. P. Panchromatic Negative	1.16
2-Solution Farmer's	M. P. Positive	1.05
Modified Belitzski	M. P. Positive	1.09
Ferric ammonium sulfate	M. P. Positive	1.12

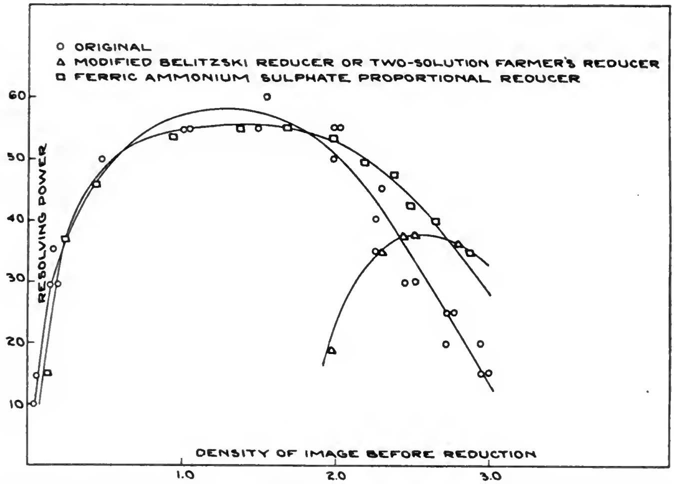


FIG. 22. Effect of reduction on resolving power of motion picture positive film.

The slight increase in the photographic as compared with the visual contrast is probably the result of a slight stain image formed during the reduction. The stain was not visually apparent when prints which had received a medium degree of reduction were projected.

Effect of Reduction on Resolving Power.—Tests were made to determine the effect of reduction upon the resolving power. Using the Sandvik reduction camera a series of non-intermittent exposures increasing in powers of 2 or of $\sqrt{2}$ were made of a suitable line subject having a contrast of 1000.[55] The exposures were made on motion picture positive and motion picture panchromatic negative film, type 2. The positive film strips were developed for 4 minutes in a tray, using the D-16 motion picture positive developer and continu-

ous agitation. The negative film strips were developed for 12 minutes in a tray, using the D-76 borax developer and continuous agitation. Samples of the developed positive and negative films were hardened in alkaline formalin solution and the images reduced in the two-solution Farmer's reducer, the modified Belitzski reducer (diluted 1:1), and the ferric ammonium sulfate reducer. The resolving power or the number of lines per mm. just visible was then determined by observation with a microscope giving a magnification of approximately 100 diameters. Graphs were prepared, plotting resolving power (before and after reduction, lines per mm.) against image density before reduction.

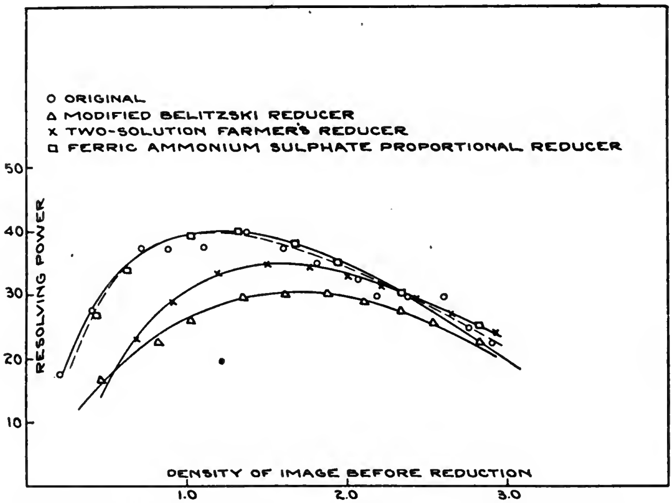


FIG. 23. Effect of reduction on resolving power of motion picture panchromatic negative film.

The curves for motion picture positive film show a notable loss in resolving power for the low and intermediate densities when the two-solution Farmer's and the modified Belitzski formulas were employed. With these reducers the resolving power for the higher densities was appreciably increased above that for the corresponding unreduced density. (See Fig. 22.) However, the resolving power of the reduced image was less than that of an unreduced image of equal density. This increase in the resolving power was apparently due to the removal of part of the image spread due to irradiation and halation effects.

The images on the positive film proportionally reduced with the ferric ammonium sulfate reducer showed no appreciable loss of resolving power. (See Fig. 22.) In the high densities the resolving power was slightly increased as a result of decreased image spread.

With panchromatic negative film the loss in resolving power on reduction was of a much lower order of magnitude than with positive film. (See Fig. 23.)

Intensification and Reduction of Sound Film Records.—Intensification and reduction of variable width and variable density sound film negatives or prints may be accomplished in the same manner as with picture negatives and prints.

With the variable width negatives the chromium and silver intensifiers gave satisfactory intensification. For prints, the use of the silver intensifier is to be preferred because the intensified image is strictly neutral in color upon projection.

The reduction of negatives or prints with variable density records may be suitably accomplished with Farmer's reducer (single or two-solution), iodine-cyanide, ferricyanide-cyanide, acid permanganate, or the modified Belitzski reducer. The contrast may be increased by intensification with either the chromium or silver intensifiers or decreased by reduction with the ferric ammonium sulfate proportional reducer.

Following is a tabulation of the results of projection tests with variable density and variable area sound records before and after intensification and reduction.

Variable Width Prints

1. Slightly overexposed print developed to normal gamma: Density reduced to normal value by treatment with two-solution Farmer's reducer. Result: Sound quality similar to that obtained with the comparison (normal) print with slight increase in ground noise.

2. Normally exposed print developed to a low gamma: Density increased to normal value by intensification with the silver intensifier. Result: Quality equal to that given by the comparison (normal) print. Ground noise slightly higher in the intensified print.

Variable Density Prints

1. Normally exposed print developed to high gamma: Density contrast decreased to normal value by reduction with the ferric ammonium sulfate reducer. Result: Sound quality equal to normal print but with slightly more ground noise.

2. Overexposed print developed to normal gamma: Densities reduced with the two-solution Farmer's reducer (subtractive reduction) to compare with

normal print. Result: Unless reduction was carefully controlled there was a tendency to lose high frequencies.

3. Normally exposed print developed to low gamma: Density contrast increased to normal value by treatment with the silver intensifier. Result: Quality similar to that of the comparison (normal) print. Ground noise slightly higher in the intensified print.

Variable Density Negatives

Two identical variable density negatives were recorded with normal exposure. One was developed to a normal gamma and the other was overdeveloped and prints made with equal unmodulated densities. The density contrast of the overdeveloped negative was decreased to compare with that of the normally developed negative by reduction with the ferric ammonium sulfate proportional reducer and a print was made from the reduced negative. The prints were then compared for quality. Result: The sound quality of the print from the reduced negative compared favorably with that of the print from the normal negative with the exception of a slightly increased ground noise.

From the above it is seen that compensation for errors in the development of variable density and variable width sound records can be made by intensification or proportional reduction. Overexposed negatives or prints may be reduced with a subtractive reducer but the latitude suffers if the degree of reduction is excessive.

PRACTICAL RECOMMENDATIONS

The following formulas and procedures are recommended for the intensification and reduction of developed images on motion picture positive and motion picture panchromatic negative film. In all cases the film should be given the following preliminary treatment.

Preliminary Treatment.—The negatives or prints to be intensified or reduced should be hardened for 5 minutes in the following solution:

Formalin Hardener (Formula SH-1)

	Metric	*Avoirdupois*
Water	500 cc.	64 ounces
Commercial formalin (40 per cent)	10 cc.	$1^1/_3$ ounces
Sodium carbonate (desiccated)	5 grams	$^2/_3$ ounce
Water to make	1 liter	1 gallon

The films should then be rinsed and immersed in a fresh acid fixing bath for 5 minutes and well washed to insure freedom from silver compounds and hypo. The wetted films should be treated before drying.

1. Chromium Intensifier.—Bleach the films completely in the following acid bichromate solution at 65°F. to 70°F. and wash for 5 minutes.

***Chrominm Intensifier* (*Formula In-4a*)**

	Metric	*Avoirdupois*
Potassium bichromate	8 grams	1 ounce
Hydrochloric acid (concentrated)	6 cc.	$^3/_4$ ounce
Water to make	1 liter	1 gallon

The bleaching time is usually from $^1/_2$ to 2 minutes. Then redevelop in the D-72 developer, diluted 1:2, or any rapid *MQ* developer which does not contain an excess of sulfite. The time of redevelopment varies from 3 to 10 minutes at 65–70°F., depending upon the degree of intensification desired. (See Fig. 4 and Fig. 5.) Then rinse and immerse in the fixing bath for 5 minutes and wash thoroughly. The film may be bleached a second time and redeveloped to secure a greater degree of intensification.

If more rapid bleaching and greater intensification are desired, add 5 grams of potassium bromide per liter ($^2/_3$ ounce per gallon) to the bleaching solution.

The formula for the stock solution of the D-72 developer is as follows:

***Elon-Hydroquinone Developer* (*Formula D-72*)**

	Metric	*Avoirdupois*
Hot water (approx. 125°F.)	500 cc.	64 ounces
Elon	3.1 grams	180 grains
Sodium sulfite (desiccated)	45.0 grams	6 ounces
Hydroquinone	12.5 grams	1 oz., 260 grains
Sodium carbonate (desiccated)	67.5 grams	9 ounces
Potassium bromide	1.9 grams	$^1/_4$ ounce
Water to make	1 liter	1 gallon

For use: Dilute one part of the stock solution with two parts of water

Keeping Properties and Exhaustion Life.—The bleaching solution and the redeveloper have good keeping properties when stored in deep tanks. If trays or shallow containers are used, the redeveloper should be prepared before use from the stock solution which may be kept in stoppered containers.

The bleaching solution was found to have an exhaustion life of approximately 150 feet of motion picture panchromatic negative film per gallon.

2. Mercury Intensifier.—Bleach the films completely in the following solution:

***Mercury Intensifier* (*Formula In-1*)**

	Metric	*Avoirdupois*
Mercuric chloride	22.5 grams	3 ounces
Potassium bromide	22.5 grams	3 ounces
Water to make	1 liter	1 gallon

Then wash for 5 minutes and redevelop in the D-16 developer or any regular *MQ* positive film developer and wash thoroughly. Repeat the process for greater density and contrast. The mercury intensifier is suitable for the intensification of titles, *etc.*, where high contrast is desirable.

To increase contrast greatly when shadow detail is not important, treat with the following solution instead of the D-16 developer.

Sodium or potassium cyanide	15 grams	2 ounces
Silver nitrate	22.5 grams	3 ounces
Water to make	1 liter	1 gallon

Dissolve the cyanide and the silver nitrate separately, and add the latter to the former until a permanent precipitate is just produced. Allow the mixture to stand a short time and then filter.

The cyanides are deadly poisonous and great care should be exercised in their use.

***Motion Picture Developer* (*Formula D-16*)**

	Metric	*Avoirdupois*
Water (about 125°F.)	500 cc.	64 ounces
Elon	0.3 gram	17 grains
Sodium sulfite (desiccated)	40.0 grams	5 oz., 130 grains
Hydroquinone	6.0 grams	350 grains
Sodium carbonate (desiccated)	19.0 grams	$2^1/_2$ ounces
Potassium bromide	0.9 gram	50 grains
Citric acid	0.7 gram	40 grains
Potassium metabisulfite	1.5 grams	85 grains
Water to make	1 liter	1 gallon

Keeping Properties and Exhaustion Life.—The bleaching solution is reasonably stable and has an average exhaustion life of 300 to 400 feet of motion picture positive film per gallon. Containers, reels, racks, *etc.*, described above for use with the chromium intensifier are suitable also for use with the mercury intensifier.

3. Silver Intensifier.—The following formula is the only intensifier known which will not change the color of the image on positive film on projection. It gives proportional intensification (see Fig. 6 and Fig. 7) and the degree of intensification is easily controlled by varying the time of treatment. The formula is equally suitable for positive and negative film and the resulting image which consists of metallic silver is permanent.

***Silver Intensifier* (*Formula In-5*)**

Stock Solution No. 1

	Metric	*Avoirdupois*
Silver nitrate	60 grams	2 ounces
Water to make	1 liter	32 ounces

Stock Solution No. 2

Sodium sulfite (desiccated)	60 grams	2 ounces
Water to make	1 liter	32 ounces

Stock Solution No. 3

Sodium thiosulfate (crystal)	105 grams	3 1/2 ounces
Water to make	1 liter	32 ounces

Stock Solution No. 4

Sodium sulfite (desiccated)	15 grams	219 grains
Elon	24 grams	351 grains
Water to make	3 liters	96 ounces

The intensifier is prepared as follows: Slowly add one part of solution No. 2 to 1 part of solution No. 1, shaking or stirring to obtain thorough mixing. The white precipitate which appears is then dissolved by the addition of 1 part of solution No. 3. Allow the resulting solution to stand a few minutes until clear. Then add, with stirring, 3 parts of solution No. 4. The intensifier is then ready for use and the film should be treated immediately.

The degree of intensification obtained depends upon the time of treatment which should not exceed 25 minutes. After intensification the film should be immersed and agitated for 2 minutes in a plain 30 per cent hypo solution and then washed thoroughly.

Life of Bath.—The silver intensifier solution prepared as above is stable under ordinary conditions for 30 to 45 minutes before a precipitate of silver forms in the solution. This precipitate then tends to deposit on the highlights of the positive image and produce fog.

A normal degree of intensification is obtained in from 10 to 25 minutes so that usually it is desirable to use a fresh solution for each treatment if further intensification is required.

***Two-Solution Farmer's Reducer* (*Formula R-4b*)**

Solution A

	Metric	*Avoirdupois*
Potassium ferricyanide	7.5 grams	1 ounce
Water to make	1 liter	1 gallon

Solution B

Sodium thiosulfate (hypo)	200 grams	1 lb., 11 ounces
Water to make	1 liter	1 gallon

Treat the negatives or prints in solution A with uniform agitation for 1 to 4 minutes at 65°F. to 70°F., depending upon the degree of reduction desired. (See Figs. 13, 14, 15, and 16.) Then immerse in solution B for 5 minutes and wash thoroughly. The process may be repeated if more reduction is desired. For the reduction of fog on motion picture positive prints one part of solution A should be diluted with one part of water.

Keeping Properties and Exhaustion Life.—The potassium ferricyanide solution will keep indefinitely when shielded from strong daylight. If hypo has been introduced by alternate treatments in the two solutions the life of the ferricyanide solution will be shortened. No exact figures can be given because the keeping life will depend upon the quantity of hypo introduced into the ferricyanide solution, and will vary according to the particular method of treatment.

The exhaustion life of the 0.75 per cent solution is approximately 300 feet per gallon.

Modified Belitski Reducer (Formula R-8)

	Metric	*Avoirdupois*
Ferric chloride (crystals)	25 grams	3 1/3 ounces
Potassium citrate	75 grams	10 ounces
Sodium sulfite (desiccated)	30 grams	4 ounces
Citric acid	20 grams	2 1/3 ounces
Sodium thiosulfate	200 grams	1 lb., 11 ounces
Water to make	1 liter	1 gallon

Mix in the order given.

Use the reducer solution full strength for maximum rate of reduction. Treat the films for 1 to 10 minutes at 65°F. to 70°F. according to the degree of reduction desired. (See Fig. 18 and Fig. 19.) Then wash thoroughly. If a slower action is desired, dilute one part of the solution with one part of water. The reducer is especially suitable for the treatment of dense, contrasty negatives.

Keeping Properties and Exhaustion Life.—The modified Belitzski reducer keeps well in deep tanks and has an exhaustion life of approximately 150 feet per gallon.

Ferric Alum Proportional Reducer (Formula R-7)

	Metric	*Avoirdupois*
Ferric ammonium sulfate (ferric ammonium alum)	15 grams	2 ounces
Sulfuric acid (concentrated)	10 cc.	1 1/3 ounces
Water to make	1 liter	1 gallon

When mixing the above formula, be careful to add the acid to the water solution and not *vice versa* or the water will boil with explosive violence.

Use the reducer solution full strength at 65°F. to 70°F. and wash the films thoroughly both before and after reduction. The film should not be left in contact with the air during reduction and washing or stains will result. The type of reduction obtained is proportional. (See Fig. 20 and Fig. 21.)

Keeping Properties and Exhaustion Life.—The reducer keeps indefinitely and has an average exhaustion life of 250 feet per gallon. Care should be taken to avoid contamination from hypo which reacts with the solution and decreases its keeping life.

CONSTRUCTION MATERIALS FOR PROCESSING EQUIPMENT

In view of the corrosive nature of many of the solutions used for intensifying and reducing, it is necessary to construct processing tanks of resistant material such as Alberene stone. Metal or wooden tanks should be coated with oxygenated asphalt.[54] Small containers may be constructed of steel heavily japanned or lacquered, or coated with oxygenated asphalt after fabrication.

Sprockets and idlers should be of hard rubber, or a resistant chromium-nickel-steel alloy such as Allegheny metal.

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DISCUSSION

MR. CHAMBERS: Were the results obtained with the tray or with the rack and tank process?

PRESIDENT CRABTREE: All of the tests were made in a tank simulating the rack and tank process; but we have made tests using the brush method which simulates machine conditions. This simply affects the rate of reduction but the nature or type of reduction is not affected in any way.

REPORT OF THE SECRETARY*

OCTOBER 1, 1930, TO SEPTEMBER 30, 1931

At the close of the fifteenth fiscal year we find the Society placed on a firmer and more permanent foundation than at any other time in its history. The position of the Society in the world of motion pictures seems definitely assured, and its value as a stabilizing element among the necessarily volatile conditions peculiar to this industry is generally recognized.

In pursuing its object to collect, correlate, and more particularly to disseminate information on the technical aspects of the motion picture art as these touch upon motion picture engineering, the Society has greatly extended the scope of its activities as followed in past years, as well as expanded the field of these activities to bring within its purview new horizons of endeavor.

MEMBERSHIP

The total membership of the Society as of September 30, 1931, was 785, classified as follows:

Honorary Members	8
Sustaining Members	14
Active Members	351
Associate Members	412
Grand Total	785

There is pending 1 membership in the Active grade.

The honorary members are as follows:

C. Francis Jenkins, Washington, D. C.
George Eastman, Rochester, N. Y.
Thomas A. Edison, West Orange, N. J.
F. E. Ives, Philadelphia, Pa.
Louis Lumière, Paris, France.
The Presidency, Société Française de Photographie, Paris, France.
The Presidency, Royal Photographic Society, London, England.
The Presidency, Die Deutsche Kinotechnische Gesellschaft, Berlin, Germany.

* Presented at the Fall, 1931, Meeting at Swampscott, Mass.

The sustaining members are as follows:

Agfa Ansco Corp., Binghamton, N. Y.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bell Telephone Laboratories, New York, N. Y.
Carrier Engineering Corp., Newark, N. J.
Case Research Laboratories, Auburn, N. Y.
Du Pont Film Mfg. Corp., New York, N. Y.
Eastman Kodak Company, Rochester, N. Y.
Electrical Research Products, Inc., New York, N. Y.
General Theatres Equip. Co., New York, N. Y.
Mole-Richardson Company, Hollywood, Calif.
National Carbon Company, Cleveland, Ohio.
Paramount Publix Corp., New York, N. Y.
RCA Photophone, Inc., New York, N. Y.
Technicolor Motion Picture Corp., Boston, Mass.

DISTRIBUTION BY SECTIONS

The participating individual membership residing under the direct jurisdiction of the three domestic sections amounts to 587. The distribution according to section is:

	Active	Associate	Total
New York Section	197	193	390
Chicago Section	27	44	71
Hollywood Section	69	57	126
Total	293	294	587

GEOGRAPHICAL DISTRIBUTION

In addition to the 587 participating individual members residing in the United States, there are 176 members residing in 24 foreign countries and territorial possessions of the United States.

		Membership	
Country	Active	Associate	Total
Argentina		1	1
Australia	1	4	5
Austria		1	1
Burma		1	1
Canada	6	9	15
China		2	2
England	21	42	63
France	12	14	26
Germany	10	11	21
Hawaii		2	2
Holland		1	1
India	4	7	11
Italy		2	2

Country	Active	Associate	Total
Japan	3	5	8
New Zealand		4	4
Norway		1	1
Poland	1	3	4
Russia		2	2
Scotland		1	1
South Africa		1	1
Straits Settlements		1	1
Switzerland		1	1
Wales		1	1
West Indies		1	1
Total	58	118	176

It is with regret that we record the deaths of the following members:

Mr. Arthur Gray
Mr. A. G. Penrod
Mr. F. G. Tutton
Mr. Donald F. Whiting

During the past year the names of 94 members were dropped from the rolls by reason of non-payment of dues. In addition, 22 resignations were received. The total decrease was, therefore, 120.

The total increase in membership due to new members was 135, of which 39 represent active and 96 associate members.

The net gain in participating individual memberships for the year was 15, making the total of this class 763.

The geographical distribution of new memberships is as follows:

New York Section	65
Chicago Section	8
Hollywood Section	17
Foreign Countries	45
Total	135

SOCIETY SECTIONS

The territory of the three sections remains unchanged as here described:

The New York Section consists of that area in the continental United States lying east of a north and south parallel passing through a point fifty miles due west of Cleveland, Ohio.

The West Coast Section consists of that area in the continental United States lying west of a north and south parallel passing through a point fifty miles due west of Denver, Colorado.

The Chicago Section consists of that area in the continental United States lying between the two north and south parallels described above.

We regret to record the passing of the London Section in accordance with a resolution canceling the authorization of the London Section, which was adopted by the Board of Governors on April 9, 1931.

A full recital of the events which culminated in this action is beyond the scope of this report. Announcements on the subject will be found in the Society's JOURNAL. Approximately 60 members, constituting fifty per cent of the membership of the London Section withdrew from the Society at the end of the last calendar year and formed themselves into a new organization named the British Kinematograph Society, with headquarters in London. The remaining members indicated their desire to retain membership in the Society of Motion Picture Engineers.

CENTRAL HEADQUARTERS

In accordance with long-cherished plans made and discussed many months prior to taking the action, the Board of Governors at the close of the Fall Meeting in New York, N. Y., October 29, 1930, selected Mr. Sylvan Harris from a list of more than seventy applicants to serve in the capacity of Editor-Manager for the Society.

Immediately thereafter a three-year lease was taken upon 500 square feet of office space at 33 West 42nd Street, New York, N. Y., to serve as the Society's headquarters. Mr. Harris is assisted by Mrs. Sally Renwick and Miss Phillis Sleeman.

PUBLICATIONS

The second year of the existence of our monthly JOURNAL finds it well established and commanding respect among the technicians of the industry. In the past year a total of 1920 pages of technical and related information were printed which included:

	Pages
Technical Papers	1338
Committee Activities	175
Technical Abstracts	67
Book Reviews	14
Patent Abstracts	61
Society Announcements	70
Committee Personnel, Addresses, *etc.*	195
Total	1920

Paid annual subscriptions and the sale of individual copies of the JOURNAL showed a satisfying increase. Unrenewed subscriptions for the year totaled 54 as compared with 88 new subscriptions received; a net gain of 34. The total number of paid subscriptions is now 207.

The total mailing list of the JOURNAL is as here shown:

Personal Memberships	763
Honorary Members	8
Sustaining Members	14
Exchanges	26
Free Copies	26
Subscriptions	207
Total	1044

The gross income from the sales of copies of the JOURNAL, *Transactions*, and reprints is as follows:

JOURNALS, 338 copies, less agency discount	\$ 525.30
Transactions, 420 copies, less agency discount	661.49
Reprints of papers published	1808.22
Total	\$2995.01

In addition to the standard publications which the Society offers for sale a number of pieces of literature are distributed free of charge to those who request them. These include the Standards booklet, Aims and Accomplishments, Membership Lists, and a booklet describing the Society's objects, its history and fields of activities. The last-named is a recent addition entitled "The Society of Motion Picture Engineers" and consists of eleven pages of descriptive matter.

The Board of Governors now has under consideration the publishing of a complete self-contained volume on the subject of Motion Picture Engineering in which the attempt will be made to treat of the various technical branches of the motion picture art. A report on the project is now being prepared.

RELATIONS WITH OTHER SOCIETIES

Our Society is extending its contacts into other organizations whose work touches upon the subject of motion pictures. We hold membership in the National Fire Protection Association, and during the past year have taken an active interest in those affairs of the association pertaining to our work.

We are also identified with the American Standards Association

under whose auspices our "Dimensional Standards for Motion Picture Apparatus and Recommended Practice," were approved and published as Item No. Z22-1930.

As the result of discussions between officers of the Academy of Motion Picture Arts and Sciences and our own Society, plans were made which are designed to make the efforts of both organizations more effective by avoiding overlapping of our respective activities.

The Society was represented at the International Congress of Photography held at Dresden, Germany, by Dr. S. E. Sheppard, of Rochester, New York.

CONVENTIONS

The Spring, 1931, Semi-Annual Convention of the Society was held at Los Angeles on May 25th–29th, inclusive. Technical sessions were held in the American Legion Auditorium, and convention headquarters were in the Hotel Roosevelt. The convention registrations numbered 139, and the banquet attendance was approximately 300. Sixty-three technical papers were presented and twenty-six manufacturers exhibited their new products.

CERTIFICATES FOR ACTIVE AND HONORARY MEMBERS

A resolution was passed by the Board of Governors to present each active member with a certificate of membership, and a committee was appointed to submit a design suitable to the purpose. In accordance with this action, a certificate of active membership was sent recently to each active member in good standing.

About two years ago the Board of Governors voted to present each honorary member with a certificate of membership, a suitable one to be designed for the purpose. This has now been done and the presentation of these certificates will be made at this meeting.

Respectfully submitted,

J. H. KURLANDER, *Secretary*

COMMITTEE ACTIVITIES

REPORT OF THE HISTORICAL COMMITTEE*

As this is the Fifteenth Anniversary of the formation of our Society it is particularly appropriate to stress the importance of the work of the Historical Committee. Our President has fittingly recognized this importance in arranging the pioneer dinner which will take place on Wednesday evening.

Because the industry which we represent has seen its principal phases evolve within the memory and experience of most of you now present, it is a hard task to force realization that these memories and experiences are fast passing into oblivion and that, if we desire to retain a record of the things for which our Society stands, we must brook no delay in preserving these records for posterity.

No other industry in history except radio has developed with such swiftness and with such far-reaching effects. There is no doubt that the motion picture and its effect on civilization will be a paramount subject with future historians. We, who are now here in the thick of the struggle, have little conception of the world changes which cinematography is bringing about in shaping the annals of the world.

There is little of the spectacular in searching the moldy records of the past. It calls for a type of mind which is often looked upon with condescension by those preoccupied with the problems of the present and the future. Perhaps it is too much to expect that the younger members of the Society withdraw momentarily from their forward-looking pursuits to render tribute to those who constructed the foundation on which they are now building.

Conflicting claims of pioneers still living, intolerances and jealousies in the memories of more recent workers, all go to render the task of the Historical Committee most difficult. To run down the evidences submitted, to sift the records and search for witnesses who have retired from active life, is a task which calls for endless and

* Presented at the Fall, 1931, Meeting at Swampscott, Mass.

monotonous work and which often arouses bitter enmities and unexpected antagonism.

Despite these difficulties the Committee has carried on, handicapped by having practically no funds and having to go on with the fore-knowledge that the work accomplished is almost purely for the benefit of posterity and of little interest to the present.

Unfortunately, most of the members residing in the East were not able to be present at the Coast convention and see the historical exhibit arranged by Mr. William Earl Theisen, head of the Museum Section of the Historical Committee. An account of this exhibit with illustrations will appear in an early issue of the JOURNAL. This exhibit is now on view in the Museum of the City of Los Angeles.

The Committee again recommends that the work of Jean Acme LeRoy and Eugene Lauste be recognized in some fitting manner by the Society. The records of these men have been published in the JOURNAL and are too long to be reiterated here.

Work on the collection of historical data has gone steadily forward and a number of large loose-leaf scrap books suitable for deposition in a museum or public library have been prepared. These scrap books are classified, mainly according to outstanding personalities in the early days of the industry. Among these personalities are included: Georges Demeny, Wm. Kennedy Laurice Dickson, Thos. A. Edison, Wm. Friese-Green, C. Francis Jenkins, Eugene Lauste, Louis Aimé Augustin Le Prince, Auguste and Louis Lumière, Jean A. LeRoy, Ettienne-Jules Marey, Eadward Muybridge, and others.

The Historical Committee wishes to express its gratitude for the kindly and generous coöperation and contributions to its work of such men as E. Kilburn Scott, London; Will Day, London; Jean A. LeRoy, New York; Wm. Kennedy Laurie Dickson, Channel Islands; J. Tarbotton Armstrong, Museum of the University of California; J. Waldemar Kaempffert, Museum of Science & Industry, Chicago; F. C. Brown, Museum of Peaceful Arts, New York; D. D. Jackson, Chemical Museum, Columbia University; A. J. Olmstead, Smithsonian Institute; Dr. Bryan, Los Angeles Museum.

The Chairman of the Committee also wishes to express his thanks to the members of the Committee for their able assistance, particularly to the unflagging zeal of President Crabtree, C. Francis Jenkins, Glenn E. Matthews, Merritt Crawford, Terry Ramsaye, Oscar Depue, F. H. Richardson, and W. E. Theisen, who have contributed greatly to the work of the Committee.

A large amount of historical data has been published, both in the technical and the popular magazines, and much of the material published has been directly or indirectly the result of the work of the Committee.

C. L. GREGORY, *Chairman*.

E. W. ADAMS	O. NELSON
M. CRAWFORD	T. RAMSAYE
O. B. DEPUE	F. RICHARDSON
C. F. JENKINS	W. E. THEISEN
G. E. MATTHEWS	F. J. WILSTACH

DISCUSSION

MR. RICHARDSON: I should be delighted to present to the Society, when some means are provided for taking care of them, some old pictures that I possess, one of which is one of the first reels that the old Bioscope Company made. I also have an old photograph of the first motion picture theater of which there is any written record.

Four years ago, when visiting the International Projector Corporation I asked to see one of their old mechanisms, but was informed that they did not have any. I looked around, and in a lumber room, under a mass of scrap, I found some astonishing things. In the dirt and dust, as Mr. Griffin will remember, I found some old projector mechanisms that I didn't believe existed any longer. There was the old Selig, and the old pink Bioscope claw-feet projector. I do not know whether the International Projector Corporation could be persuaded to give them to the Society, but they certainly ought to be preserved in a museum.

PRESIDENT CRABTREE: I should like to make a plea to everybody who has apparatus of historical interest, that they offer it to the Historical Committee for placing in a suitable depository. We have two possible depositories, one in the East and one in the West. The one in the West is of little use to us in the East, and *vice versa*. I believe that attempts were made to establish one in Washington, but there has been much objection to that because it would not be accessible. The motion picture industry in the East is centered in and around New York City. We want this exhibit to be of value, and not something which is going to collect dust and never be looked at.

MR. GREGORY: Mr. President, probably a great many of you are unacquainted with the Museum of Peaceful Arts, which is in the new News Building at 220 East 42nd St., New York, N. Y. The idea of this great museum, which covers two floors of that building, is to be situated in the heart and center of things, so as to prove of easy access to any one visiting New York City, or who lives in the city. This museum has ample space for the presentation of any motion picture material which may be loaned or given, and the director is quite willing to accept things as a loan. If conditions require, any exhibit so loaned may be recalled, and replaced in a more suitable depository. Mr. F. C. Brown is the director of the museum. The space which was available at the Smithsonian Institute is already filled. If important exhibits are given to this museum, they can replace

some of their less important exhibits, which would be put into storage. But any exhibits donated to the Smithsonian Institute would have to be very important in order to receive a place where the ordinary visitor could inspect them.

MR. MATTHEWS: In connection with the provision made for apparatus, I should also like to make a plea for those members who, as a hobby, occasionally browse among old bookshops and libraries, that they watch for early articles on motion pictures, and have photostats made of any papers that seem to be pertinent to the early history of the motion picture. These should be sent to the Secretary's office, in New York. Very interesting material, which should be recorded in our records but which is promptly lost or forgotten, is continually being unearthed by different members.

MR. RICHARDSON: I do not believe that the matter of accessibility is as important as the matter of permanency. We should establish a museum for the benefit of those to come, when you and I are gone.

I suggest that the President appoint a committee to confer with the Smithsonian Institute to find out if space could not be made available for a motion picture exhibit.

PRESIDENT CRABTREE: The Historical Committee can attend to the matter.

MR. GREGORY: I made a special trip to Washington to see the officials of the Institute; the remarks which I made about their limited facilities are the result of that trip.

MR. RICHARDSON: Did you remind them that the motion picture industry is the fourth largest in the United States, and that it wants to establish a museum for posterity?

MR. GREGORY: Yes. They did not seem to be convinced, but said there was much other material of great importance, and that they could not enlarge the present building. Their thoughts may change if their facilities are improved, but until additional appropriations are made, they do not see any other means except to retire exhibits of less importance as exhibits of more importance come in. There is available a room about 40 by 60 feet in size, which is pretty well filled at the present time.

PRESIDENT CRABTREE: The problem apparently is to convince the authorities that the motion picture industry is much more important than they seem to think it is. I believe the suggestion is in order for the Historical Committee to make further efforts.

MR. FARNHAM: The Committee might have included in its report a note to the effect that some of the large companies maintain historical exhibits. The Bell Telephone Laboratories has an exhibit of equipment, and our company preserves its historical lamps. Although these companies will undoubtedly keep these collections intact, the fact should be on record that they exist, in case any one should want to look up historical material.

MR. J. R. CAMERON: Mr. E. S. Porter, who is present at the Convention, has with him the original Simplex projector built by him in about 1898; I am sure he would be pleased to show it to anyone who may be interested.

ABSTRACTS

Undersea Photography with an Eyemo. ALFRED L. GILKS. *Amer. Cinematographer,* **12,** October, 1931, p. 9. A camera case has been developed for underwater cinematography which makes the practical advantages of the hand camera available in this special type of work. It allows all the usual adjustments such as focusing, winding, and sighting to be made under water. Reloading is the only operation for which the outfit must be taken to the surface, and even this may be done quickly, due to the construction of the casing. The fogging of exposure ports has been overcome by filling the case with chemically dried air. The refraction effect of the water requires specially calibrated focusing dials which are adjusted by tests under actual operating conditions. A submarine camera of this type accompanies the Vanderbilt Oceanographic Expedition.

A. A. C.

Trans Lux Rear Stage Projection. WILLIAM MAYER. *Mot. Pict. Projectionist,* **IV,** October, 1931, p. 13. A short description is given of the projection room arrangement used in Trans Lux houses. The projection distance is eight feet, and the picture eight and one-half feet wide. Two projectors are placed as close together as possible behind the center of the screen, inclined each at a $22^1/_2$-degree angle on opposite sides of the screen centerline. A reflector is used in the lens system for reversing the image, so that projectors and sound heads are threaded in the usual way. The loud speaker baffles are located below and close to the bottom of the screen, an arrangement which is said to produce good sound illusion. The chief advantages of rear projection claimed are: cheaper, more compact theater construction; lessened fire hazard, and the possibility of a comfortable level of illumination in the auditorium. A. A. C.

Sound Motion Pictures and Education. GORDON S. MITCHELL. *Proj. Eng.,* **3,** October, 1931, p. 7. The growing interest in the use of sound motion pictures in schools is emphasized in this article. It cites as evidence the attention paid to this method of instruction at the recent Los Angeles convention of the National Education Association and the report of Federal Commissioner Cooper on tests designed to determine the absolute value of the sound picture in educational work. There follows a discussion of the projection equipment necessary for showing the educational picture, concluding with the opinion that all branches of the motion picture industry should prepare for the opening of this new field of activity. A. A. C.

Study of a Pick-Up Arm. A. LOVICKI. *Technique Cinemat.,* **2,** August, 1931, p. 9. In the usual form of needle mounting on a sound record pick-up arm, the angle made by the needle with the tangent to the record groove at the point of contact varies considerably from start to finish of the record. It is proposed that the needle be mounted at an angle to the axis of the arm, and the length of the arm be changed so that the direction of the needle will be nearly tangent to the groove at all points throughout the playing of the record.

C. E. I.

Ventilating of Rooms. G. LYON. *Technique Cinemat.*, **2,** August, 1931, p. 3. The author describes a number of experiments made with rabbits which indicate that the air in a confined space becomes poisonous due to accumulation of toxic substances given off in breathing. It is shown that the effects noticed are not due to increase in carbon dioxide content or diminution of oxygen. The toxic substances can be destroyed by the admixture of ozone to the air in a circulation system. The purified, filtered and humidified (or dehumidified) air from the recirculation system should be led into the room under the chairs and removed at the ceiling so as to effect a steady replacement with a minimum of mixing.
C. E. I.

Askania Model "Z" and 4-Cassette Cameras Made for the Geyer Company in Berlin. *Filmtechnik*, **7,** August 22, 1931, p. 1. Several improvements in the mechanism have been made in the model "Z" to make it more silent running. The film channel and optical system have also been changed to minimize the danger of the film plane-to-lens distance becoming changed by mechanical injury.

The 4-cassette camera is, in principle, the same as the model "Z" but it has four cassettes, one on each side of the drive. Those on the right, looking forward, are the feeding cassettes, while those on the left are the take-up cassettes. In making pictures by the Dunning process, the back cassettes contain a yellow-dyed positive film which lies in the film window in front of the unexposed negative, which is contained in the front cassettes. In color photography, the negative film carrying the filter is placed in the back cassettes.

Askania has also a new device for making exposures at intervals varying from 20 seconds to 10 hours. The above pieces of apparatus were shown for the first time at the exhibition in connection with the Eighth International Congress of Photography at Dresden. W. C.

Development of Cinemicrography. H. LINKE. *Filmtechnik*, **7,** June 27, 1931, p. 1. The author surveys the best-known outfits for cinemicrography, and describes the Askania apparatus in detail. In this assembly, the microscope, the camera, and the light source are mounted on independent supports. A 55-ampere, self-regulating arc is used, and the appliances available render it possible to cover a range of exposure frequencies from 100 a second to one every 10 hours. W. C.

The Application of the Motion Picture to the Problem of the Rising Cost of Education. B. A. AUGHINBAUGH. *Educat. Screen*, **10,** September, 1931, p. 193. The greater masses of children attending school, the rising age limit before leaving school, and the better equipment and broader curricula of modern schools, all make the rising costs of education inevitable under the present system. The American public must either cease complaining and pay these costs or "find some way for imparting this mass education by mass production methods." Motion pictures represent a new system for imparting knowledge that is more efficient than words and reading. The cinema is both quicker and more accurate
R. P. L.

The History of Motion Pictures. E. LEHMANN. *Kinotechnik*, **13,** July 5, 1931, p. 223. The early history of motion picture developments in America, England, France, and Germany is reviewed and the rival claims to the invention

of motion pictures are considered. It is concluded that the question of the time of the inventions is, of itself, superficial. It appears most important to the author to determine the ones to whom credit is due for the ideas and constructions in the forms which are decisive for the development of modern motion picture practice. These are, in his opinion: Marey, with the entire camera technic; Edison, with his perforated film; Demeny, with his intermittent movement and take-up spool; the Lumières, with the pull-down movement and their entire construction of apparatus; and Continsouza, with the tangential Maltese cross. It is thought impossible to credit any one person with the invention of motion pictures. M. W. S.

The Breaking of Condenser Lenses. K. MARTIN. *Kinotechnik*, **13**, July 5, 1931, p. 228. The cause of breakage of large condenser lenses with sudden changes of temperature is thought to have been traced to minute chips on the ground edges of the lenses. It is claimed that the difficulty was largely overcome by polishing the edges as well as the surfaces of the lenses. M. W. S.

New Light on Color Problems. T. T. BAKER. *Kinemat. Weekly*, **176**, October 1, 1931, p. 59. The author deals briefly with several aspects of natural color cinematography. Recent developments have shown that proper color rendering may be obtained with spectrum divisions other than the conventional three primaries, blue-violet, green, and orange, and that the filters may be lighter than theoretical provided the exposure is adjusted so that only the desired band is registered on the negative. Ordinarily, gradation varies with the wavelength of the exposing light, but experiments have shown that a suitable ratio of gelatin to silver in the emulsion can bring about an equality of gradation for all wavelengths, provided development is carried to completion. H. P.

Camera Cover Reduces Bulk. *Mot. Pict. Daily*, **30**, September 15, 1931, p. 40. A cast duralumin sound camera housing which is evacuated when in use has been designed by a Hollywood technician. Microphones may be placed within two feet of the camera without recording any sounds from the movement. Such insulating materials as sponge rubber, fiber, asbestos wool, *etc.*, are said to be unnecessary with this new type of camera "blimp." G. E. M.

New Sound Printing Device from Bell and Howell. *Mot. Pict. Herald*, **104**, September 5, 1931, p. 42. Five apertures are cut in a 220-degree drum and indexed to facilitate quick operation by withdrawing a pin and moving a lever. The five apertures consist of one full opening, and one opening each for sound and picture printing, for either forward or reverse movement of film through the printer. G. E. M.

New RCA Portable Projector. *Mot. Pict. Herald*, **104**, September 5, 1931, p. 47. The unit consists of a projector, amplifier, loud speaker, and a film-carrying case, having an aggregate weight of 200 pounds. The speaker is of the flat baffle type, and fits in a case, $8^1/_2$ by 19 by $14^1/_2$ inches in size. Adequate reproduction is possible for a room of 75,000-cu. ft. content with this 8-inch directional baffle. For smaller rooms, of not more than 12,000 cu. ft. capacity, a 6-inch dynamic cone speaker is supplied. An 8- by 10-ft. picture is obtained with a 75-ft. throw. The apparatus is operated on 105 to 125 volts a-c. A 1000-ft. standard reel is accommodated on the projector. G. E. M.

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ABSTRACTS OF RECENT U. S. PATENTS

1,819,047. **Portable Motion Picture Camera.** J. E. THORNTON. Assigned to J. O. O'Brien. August 18, 1931. Motion picture camera in which the film supply spool and film receiving reel are mounted in alignment at opposite ends of a camera case or frame, thus providing a long but narrow package suitable for carrying in the hand. The threading of the film through the parts of the camera is so arranged that the camera case is not appreciably wider than the film. A two-part container is provided for housing the casing, which container may be opened sidewise for providing a mounting for the camera.

1,819,327. **Eliminating Distortion and Creating Stereoscopic Effects in Motion Pictures.** G. GRIFFITH. Assigned to Griffith Camera Corp., Ltd. August 18, 1931. A projector is located in a remote position with respect to a projection screen which has an arcuate surface. The convex side of the arcuate surface of the screen faces the projector. A mechanism is provided for imparting movement to the projector in a horizontal plane and in an arcuate path concentric with the surface of the screen within predetermined limits. The mechanism for bringing about the reciprocation of the projector in an arc track is a shuttle-like back and forth movement operated from the driving motor through a lever and crank connection. The motor is timed to operate the lever and crank in synchronism with the motion picture projection.

1,819,476. **Lens Mount.** F. H. OWENS. Assigned to Owens Development Corp. August 18, 1931. A longitudinally adjustable lens holder is provided for carrying a lens. A support is provided for mounting the lens holder, and there is a resilient member engageable with the holder for locking the holder in adjusted position. The holder will accommodate lenses which may vary slightly in focal length, and will permit accurate adjustment of the focus.

1,819,492. **Taking Positives Directly on Disk of Photographic Material.** J. H. WHITE. Assigned to H. Germain. August 18, 1931. A camera employing a direct positive exposure of the image or series of images on an annular surface adjacent the periphery of a light-sensitized disk of paper or like photographic material is provided, and intermittently directed therethrough. The intermittent movement is obtained by action of a radially disposed spring secured to a radially extending arm which may be successively moved to different angular positions for a time period sufficient to effect each successive exposure. The spring is flexed as the radially extending arm moves step by step for completing each successive exposure or picture reproduction.

1,819,541. **Printer with Plurality of Copying Lenses.** H. O. CARLETON. August 18, 1931. A motion picture printing machine having a plurality of copying lenses is provided. Each lens is adapted for projecting onto a sensitized film strip an independent image similar to that on an image-bearing strip movable in synchronism. The lenses are adapted for concurrent action and each is adjustable toward and from the image-bearing film strip and the sensitized film strip. Two of the lenses are adjustable in a vertical plane up and down and to

the right and left. Three copying lenses are supported on mounts shiftable in guides. There are screw shafts fixedly secured to the guides and threadably engaging the mounts to adjustably move and focus the lenses. Three similar images are printed laterally of the film. With the apparatus of this invention a series of images carried by a film-strip of standard width may be reproduced in multiple to secure on a strip of equal width three like series of smaller images, each adapted for use in a projecting apparatus of smaller size.

1,819,593. **Simplified Camera with Special Sprocket Construction.** R. A. CLAPP. August 18, 1931. Simplified construction of motion picture camera having means for retaining the film in contact with the sprockets or feeding device for insuring positive movement of the film during the operation of the camera. This means comprises a pair of rollers, such as rubber or similar material, each provided with a pair of bifurcations to accommodate the teeth of the sprockets. These rollers are mounted in frames which, in turn, are under spring pressure or tension, thus insuring constant pressure of the rollers against the film, and of the film against the sprockets. An eccentric is provided with an arm connected at its upper end thereto. The eccentric may be rotated for advancing he arm in step-by-step movement. The arm carries prongs which engage the perforations in the film for moving the film past the aperture in a step-by-step movement. There is a shutter operated by the eccentric rotating means in synchronism with the movement of said arm to cover the aperture at predetermined intervals. The structure is intended to provide an intermittent step-by-step movement in synchronism with the operation of the shutter in a compact structure.

1,819,776. **Sound and Picture Screen.** J. C. HECK. Assigned by mesne assignments to The Da-Lite Screen Co., Inc. August 18, 1931. A screen for the reproduction of motion pictures accompanied by sound which consists of a single thickness finely woven textile fabric screen having a front light reflecting surface to receive the projected pictures, and provided with perforations therethrough in number and size sufficient to permit passage of sound waves therethrough of appropriate volume without blurring, while at the same time preserving the light-reflecting properties of such surface sufficiently to constitute an efficient screen for the presentation of the pictures, the walls of the perforations being substantially at right angles to the body of the screen.

1,819,820. **Photographic Sound Records on Rotating Plate.** E. L. KENT. August 18, 1931. Sound is recorded on a circular plate which is rotated in front of a light source disposed on one side of the plate. On the other side of the plate and in a position to receive light waves projected from the light source through the plate, in accordance with the circular paths of the sound record thereon, is a light-sensitive cell arranged and adapted to be acted upon in accordance with the change in intensity to effect reproduction of sound in accordance with the circular record on the plate.

1,819,883. **Composite Negatives for Novelty Pictures.** M. FLEISCHER. Assigned to Out of the Inkwell Films, Inc. August 18, 1931. Apparatus for producing novelties in pictures, in which a particular figure may be shown in action or in repose at any point on a background. The figure in action may be retained throughout a definite portion of a number of frames, while simultaneously showing the consecutive movements of the figure. A composite negative

is produced having a series of pictures of a background involving moving elements in different poses, by means of which a frame of the film may be projected on a screen and a selected pose of the moving object disclosed by the projected frame masked. The projected frame is photographed and then the background, except the selected pose, is masked and photographed. Then the selected poses are photographed on as many raw stock frames of the negative in a sequence, as the selected poses initially appear on the projected frames for retaining selected poses in suspended positions.

1,819,981. **Multicolor Cinematograph Film Material.** J. E. THORNTON. August 18, 1931. A film for use in the production of multicolor cinematograph or other film positives in four or three colors, in which half of a picture is formed in one layer of colloid upon one piece of film, and the other half of the picture in one layer of colloid on a second piece of film, each layer and each half-picture containing two colors interspersed or intermixed in close juxtaposition.

The film strip is initially double standard width and half standard thickness, having upon its surface two stripes of colloid running side by side longitudinally of the film, each stripe formed with a mosaic pattern therein of fine lines, dots, or grains, the strip of material being adapted to be severed longitudinally after printing, and the images printed upon one strip being superimposed upon the images printed upon the other strip.

1,820,054. **Light Guard for Motion Picture Projection Machines.** A. DINA. Assigned to International Projector Corp. August 25, 1931. A projection machine having the light beam between the projector and the film housing wholly enclosed by a shield. The projection head has an aperture opening upon which the light beam is directed. A perforated shield extends around a portion of the beam adjacent the projection head. An end wall is formed on the shield, which end wall is apertured to define the area of the light beam falling upon the aperture opening. The light beam is permanently shielded from the operator's eyes and the light concentrated on the light aperture where required.

1,820,335. **Intensity Control of Facsimile Transmission System.** O. VON BRONK AND H. RUKOP. Assigned to Gessellschaft für Drahtlose Telegraphie m. b. H. August 25, 1931. Facsimile transmission and reception system in which the sensitiveness of the picture transmission and reception system is automatically adjusted in accordance with the prevailing intensity or volume of reception. If reception is strong, the sensitivity must be made small, while the sensitivity must be great whenever the incoming signals are weak. This is accomplished by providing a receiver arrangement with an integrating action during a period which is long compared with the radio-frequency period or picture-element period (fractions of a second); for example, a simple rectifier with collecting condenser produces a direct current whose strength varies in conformity with the volume of reception, the direct current altering, for instance, by varying a grid potential, the sensitiveness of the picture reproducing apparatus in the desired manner. Since the fading or intensity fluctuations are generally of a period amounting to several seconds, such an integrating device of low inertia is capable of compensating a large part of the intensity fluctuations. At the receiving station, an amplifier is provided with its output connected to the light source of the facsimile recorder. An auxiliary circuit is provided for periodically illuminating a source of constant light intensity.

The relative intensities of the two light sources are compared. The light variations in the first source are employed also to govern the application of a bias potential to the amplifier so that the strength of the received signals is controlled in proportion to the received signals or reception at any given instant, thereby enabling the sensitiveness of the receiver to be controlled accurately.

1,820,418. **Camera for Obtaining Relief Effect.** C. WILLIAMS. August 25, 1931. A motion picture camera for photographing an object from two different angles in the same horizontal plane or in different planes so that when the photographs are projected in rapid succession in the usual manner, a "relief" or "perspective" effect is produced to impart to the object seen an appearance of reality or solidarity. The camera includes an optical chamber with a lens disposed within the chamber. The optical chamber lens and motion picture film, which is driven in the path of the lens, are moved synchronously as a unit to different positions for making exposures of the object from different angles.

1,820,484. **Focusing Lens Mount.** F. H. OWENS. Assigned to Owen Development Corp. August 25, 1931. A focusing lens mount which comprises a lens holder and a longitudinally adjustable carrier. The carrier provides a coarse adjustment for the lens holder. There is a supporting means in which the carrier is rotatable for effecting longitudinal adjustment of the holder which, when once adjusted, is then locked in position. A fine adjustment is also provided for the lens holder for precision focusing of the lens.

1,820,731. **Rewinding Mechanism.** M. DAINOW. August 25, 1931. The reels carrying the motion picture film in a home type portable projector are provided with crank members which may be moved to a projected operative position or to an inoperative position to permit either of the reels to be used alternately as a driving reel or a take-up reel. Each reel is provided with a hinged member constituting a crank handle which is pivotally mounted on the reel. When the crank is moved to an extended position it may be used for driving the reels. However, when the crank handle is restored to the housed position it serves to lock the reel on the shaft as a supply reel permitting the film to be unwound therefrom to a take-up reel.

1,820,739. **Motion Picture Collapsible Screen Frame.** J. T. HECK. Assigned to Da-Lite Screen Company, Inc., by mesne assignments. August 25, 1931. A projection screen which can be folded into a relatively small rectangular carrying case and carried upon a spring actuated roller therein. The screen is mounted upon a spring actuated roller and is provided with hinged link members which serve as struts for holding the screen taut for projection purposes. The struts are each mounted under spring tension to enable the screen to be stretched for the exhibition of pictures.

1,820,959. **Safety Device for Motion Picture Projecting Machines.** T. T. ALLEN. Assigned to Sentry Control Corp. September 1, 1931. A safety attachment for motion picture projectors wherein a switch is mounted upon a plate member adapted to be arranged at predetermined spacial relation with respect to the framing plate. The switch is operated by a centrifugal drive for opening its contact, in the event of breaking of the film, for cutting off the driving motor circuit and operating the shutter for the protection of the film against fire, pending repair of the mechanism.

1,821,399. **Apparatus for Indicating Printing Light Values.** F. H. OWENS.

Assigned to Owens Development Corp. September 1, 1931. Photographic films used in the production of motion pictures may be provided with a test gauge for determining the proper light value to be used in printing films. The film is moved past a printing station and is subjected to the exposure from a printing lamp through a graduated strip on a test portion of the film. An exposure is thus made on the film which, when the film is developed, comprises sections of graduated densities inversely corresponding to the sections of the graduated strip through which the exposure is made. The film is thus provided with a test strip which may be used as a basis of comparison with the exposures on the film for determining the printing light value to be used in printing the film.

1,821,416. **Method of and Apparatus for Picture Transmission.** E. BELIN. September 1, 1931. A circuit for transmitting picture modulations for facsimile transmission and reception wherein the picture modulations consist of non-oscillatory electrical variations for controlling a translating mechanism. An oscillator is arranged to generate waves of a frequency sufficiently low to actuate the translating mechanism. These low frequency oscillations are modulated with picture modulations and are then utilized to control the carrier wave. At the receiver the low frequency modulated currents are used to operate a recorder for reproducing the picture modulations effected at the transmitter.

1,821,515. **Device for Protecting Films against Ignition.** K. HOFFMANN, *et al.* Assigned to Zeiss Ikon Aktiengesellschaft, Dresden. September 1, 1931. An automatic protecting device for films, which device is actuated for automatically protecting films against ignition in the event that the film should break. A protecting shield is shifted between the projection window and the light cone as soon as a break in the film band occurs, and the movement of the shield operates a switch controlling the motor operation. Means are provided to allow a resetting of the parts into their original operative position as soon as the break in the film band has been repaired.

1,821,538. **Method and Means for Producing Illuminated Motion Effects.** H. B. BARKER. September 1, 1931. A pictorially decorated translucent front wall is arranged across an advertising sign, behind which there are arranged sets of heat motor devices, each of which carry cylindrical screens having markings thereon for producing variable pictorial representations upon the advertising sign. The rotary screen which is driven by a heat motor has lines inclined horizontally and at an angle for directing upon the advertising sign successively variant light rays which produce a pictorial effect on the front of the screen for arresting the attention of an observer.

1,821,557. **Apparatus for Producing Motion Picture Effects.** A. B. LEECH. September 1, 1931. An advertising sign which includes a heat operated motor which drives a cylindrical screen through which light is projected upon an object screen for producing the illusion of motion traveling in a direction opposite to the direction of movement of said movable screen. The movable screen carries inclined opaque lines thereon, which lines are alternately disposed with respect to transparent lines. Light is passed through the movable screen and through the lines to an object screen for producing various illusions.

1,821,626. **Method of Producing Projection Pictures.** F. FLEISCHER. September 1, 1931. Apparatus for advertising and entertainment purposes in

which motion pictures may be projected upon an inclined transparent reflecting surface opposite an observing window through which the motion pictures may be observed. A plurality of spaced parallel transparent picture carrying plates are exchangeably positioned on one side of the angularly disposed reflecting surface in the chamber. A source of light is adjustably positioned behind the picture plates so as to send its rays through them toward the reflecting surface. There is a projecting surface for projected pictures substantially disposed at a right angle to the picture carrying plates. A motion picture projector is arranged behind the projecting surface for producing motion pictures on the projecting surface which may be viewed by reflection from one side of the reflection surface on which the reflection of a stationary picture from the plurality of picture carrying plates already appears. By this association of a transparent reflecting plate with the stationary picture reproduction superimposed with motion picture reproduction, the observer sees a delusion picture intended to arrest the attention and usefully perform its service as an advertiser.

1,821,630. **Regulator for Sound Reproducing and Synchronizing Machines.** C. H. GARRETT AND B. G. HERBER. September 1, 1931. Gearing for synchronizing the operation of a phonograph record turntable with the movement of a picture film for synchronously reproducing sound from the photographic record with respect to the projection of pictures. The phonograph turntable has an internal ring gear. A vertically disposed shaft having a driving gear thereon is mounted so that the driving gear imparts motion to the ring gear through an intermediate gear. There is a bushing surrounding the vertical shaft with a ring extending around the bushing, the ring having an integral arm extending therefrom and affording a bearing for the intermediate gear. Spring means are provided on the arm to relieve the tension of the ring with respect to the drive shaft at the same time that the intermediate gear is permitted to shift in position about the main drive gear. The frictional governor applied to the main drive shaft is varied whenever it is desired to bring the phonograph into synchronism with the motion picture projection and without removing the stylus from the sound record.

1,821,680. **Multiplex Film and Process of Making.** L. T. TROLAND. Assigned to Technicolor Motion Picture Corp. September 1, 1931. A film is provided having a series of complemental images, two images of each complemental set being taken from the same point of view at the same time, and a third image of each set being taken from the same point of view at a slightly different time. The records on the film give red, green, and blue color aspects. The red and green records representing simultaneous aspects are reversed with respect to each other, and the blue records represent alternate aspects. The respective images of each complemental set are substantially alike, so that they may be accurately registered with respect to each other without noticeable color fringes. This method is intended to minimize the registration difficulties due to shrinkage and expansion of the film, which affords a short distance between objective and film, and which permits the use of film in one or more strips for the several series of images.

In the case of rapidly moving objects, the pictures formed through the filters at successive intervals of time will not register precisely, resulting in a tendency toward color fringes; but by taking the red and green records simultaneously

they will register exactly, and when using only a single additional color such as blue, fringes will not be noticeable for the reason that the blue record, which is colored yellow in the final picture, does not contribute largely to the definition of the picture; and to a lesser degree, the same is true of the blue-green record in the four-color example.

1,821,698. **Light Indicating System and Method.** G. R. FISHER. Assigned to Federal Telegraph Co. of San Francisco, Calif. September 1, 1931. A circuit responsive to variations in light intensity wherein an impedance which changes its resistance under the action of variable light rays is connected in circuit with an electron tube. The tube is adjusted to a critical condition of oscillation so that a substantial decrease in light intensity falling upon the tube will initiate an uninterrupted current flow through the tube. The circuit associated with the tube has its values so adjusted that substantially no oscillatory current flows for a given light intensity while for a slightly decreased light intensity oscillations can be initiated. The light operated circuit may be used wherever it is desired to operate a circuit upon a decrease in light intensity below a predetermined level.

1,821,775. **Film Controlled Switch.** H. C. TITTLE. Assigned to General Electric Co. September 1, 1931. A switch device is operated by the film as it reaches the end of the reel for reversing the driving motor for effecting a rewinding of the film without removing the film from the projector. The switch mechanism comprises a roller mounted upon a stud, the film passing over the roller and engaging flanges at opposite ends of the roller. One of these flanges is arranged under spring tension in such manner that the flanges tend frictionally to engage opposite edges of the film. One flange is mounted under axial spring tension, and is adapted to shift a contact under conditions of axial movement of the flange. This axial movement is effected adjacent the end of the path of travel of the film by reason of a cut away depression in the edge of the film adjacent the end of the path of travel thereof. As the contact is closed a reversal of the driving motor circuit is effected for obtaining a rewinding operation for the film without removing the film from the projection machine.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

BOOK REVIEW

Sound Film Recording and Reproducing by the Klangfilm Process (Klangfilm-Tobis System). (Tonfilm Aufnahme und Wiedergabe nach dem Klangfilm-Verfahren (System Klangfilm-Tobis).) Dr. F. Fischer and Dr. H. Lichte. *S. Hirzel,* Leipzig, Germany. 450 pages, 378 illustrations. Theoretical and practical knowledge of sound recording and reproducing from many sources has been collected in this volume, making it a summary of theory and a handbook describing the workings of the systems in use at present.

After an outline of the three sound systems, *viz.*, variable density recording, variable width recording, and wax disk recording, the authors describe the fundamental parts of the apparatus, such as the Kerr cell, the oscillograph, optical systems, photosensitive devices, wax disk engravers, and pick-ups. A full treatment is given of the theory of photographic sound reproduction, including a discussion of non-linear distortion introduced by incorrect photographic processing. Theories of various types of microphones, loud speakers, and amplifiers are presented, as well as a study of the distortion which may be introduced.

The second part of the book deals with the design of Klangfilm apparatus, describing in turn the recorder, various sound film attachments for projectors, disk recorders and reproducers, recording and reproducing amplifiers, portable amplifiers and news cameras, developing and printing, and dubbing.

The book is concluded with a discussion of room and building acoustics, and a detailed description of a typical installation in the Ufa studios.

The material presented appears to be very accurate; much of it has never heretofore been available in a compiled form. The illustrations are well drawn, and help greatly to clarify the text. The book can be highly recommended to any one wishing to study all aspects of sound pictures.

V. C. Hall

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L. E. CLARK, *Treasurer*

CONTRIBUTORS TO THIS ISSUE

Burt, R. C.: Born December 2, 1896, at Battle Creek, Mich. E.E., Cornell University, 1921; Ph.D., California Institute of Technology, 1926; research, General Electric Co., 1918–20; Western Electric Co., 1920–21; research fellow. California Institute of Technology, 1921–30; director, Burt Scientific Laboratory.

Crabtree, J. I.: See January, 1931, issue of JOURNAL.

Giles, L. W.: Born July 14, 1902, at Florence, Mass. B.S. in E.E., Worcester Polytechnic Institute, 1925; development of transmission instruments involving magnetic circuits, Bell Telephone Laboratories, 1925 to date.

Hunter, C. R.: Born July 2, 1890, at Oakland City, Ind. U. S. Navy, 1907–11; commercial photography, 1911–15; laboratory technician, Universal Pictures Corp., 1916–21; Chief, Photographic Division, Universal Pictures Corp., 1921–28; director of sound and photography, Universal Pictures Corp., 1928 to date.

Jones, W. C.: See January, 1931, issue of JOURNAL.

Muehler, L. E.: Born May 27, 1902, at Sullivan, Ind. B.S. in chem. eng., Rose Polytechnic Institute, 1927; projectionist, 1920–22; radio sales and service, 1923; research photographic chemist, Eastman Kodak Company, 1927 to date.

Pierce, R. M.: Born August 24, 1878. Amateur photographer, 1894; portrait photography, 1896–1900; motion picture road show, 1900–02; kodak finishing, 1912–18; Universal Pictures Corp., 1919 to date.

Stanton, G. T.: Born July 4, 1895, at Batavia, Ill. B.S. in E.E., Case School of Applied Science, 1920. Two years of military service, Rainbow Division. New York Central Lines, 1920–29; Electrical Research Products, Inc., 1929; acoustic consulting superintendent, Electrical Research Products, Inc., 1930 to date.

Wolf, S. K.: Born August 29, 1901, at Baton Rouge, La. B.S., Louisiana State University, 1922; M.S., Sheffield Scientific School, Yale University, 1926; Westinghouse Electric & Mfg. Co., 1922–23; faculty, Sheffield Scientific School, Yale University, 1923–28; installation engineer, Electrical Research Products, Inc., 1928; acoustic engineer, Electrical Research Products, Inc., 1929; manager, acoustical consulting department, Electrical Research Products, Inc., 1930 to date.

SOCIETY ANNOUNCEMENTS

CHICAGO SECTION

The results of the recent election of officers of the Chicago Section were as follows:

Chairman, R. F. Mitchell
Sec.-Treas., B. W. Depue
Manager, R. P. Burns
Manager, O. B. Depue

NEW YORK SECTION

At a meeting of the Board of Managers of the New York Section held on November 5th at 250 Madison Avenue, New York, N. Y., plans and policies to be followed during the current year were discussed in addition to various financial matters involved in drawing up a budget under which to operate. The tentative plans evolved give promise of an extremely interesting series of meetings of which there will be eight, scheduled approximately one month apart.

A meeting of the Section will be held on Wednesday, December 9th, in the auditorium of the Engineering Societies Building, 33 West 39th Street, New York, N. Y. Mr. H. A. Frederick of the Bell Telephone Laboratories will repeat his paper entitled "Vertical Sound Records; Recent Fundamental Advances in Mechanical Records on Wax," which was presented at the Swampscott Convention on October 7th. A demonstration, employing considerably more elaborate apparatus than was used at the Swampscott Meeting, will be given. Leopold Stokowski, director of the Philadelphia Orchestra, will address the meeting, following Mr. Frederick's technical discussion, on the problems of recording from the standpoint of a musician.

NEW MEMBERS*

William R. Brewster (*M*)
University Film Foundation, 40 Oxford Street, Cambridge, Mass.

Charles de Moos (*A*)
Pathé Exchange, Inc., 1 Congress St., Jersey City, N. J.

* (*M*) indicates active grade; (*A*) associate grade.

ORVILLE M. DUNNING (*A*)
Thos. A. Edison, Inc., Orange, N. J.

FABJAN EPSTEIN (*A*)
Wilcza str. 29z/12 Warsaw, Poland.

HERBERT M. FORD (*A*)
Kinemas Ltd., S. A., Kinema House, 259 Jeppe St., Johannesburg, So. Africa.

WARREN D. FOSTER (*M*)
Kinatome Patents Corp., 4 Wilsey Square, Ridgewood, N. J.

HARRY GLICKMAN (*M*)
Craft Film Labs., Inc., 136–23 34th Ave., Flushing, L. I., N. Y.

OTTO GRATZER (*A*)
30 Jefferson St., Wellsville, N. Y.

LLOYD E. HARDING (*M*)
RCA Institutes, 75 Varick St., New York, N. Y.

COURTLAND HOPPIN (*A*)
72 Rue Vaneau, Paris, France.

CHARLES F. HORSTMAN (*A*)
Radio-Keith-Orpheum Corp., 1560 Broadway, New York, N. Y.

FRED H. HOTCHKISS (*A*)
Société de Materiel Acoustique, 1 Blvd. Haussmann, Paris, France.

WILLIAM DE LANE LEA (*A*)
Pathé Cinema, 6 Rue Francoeur, Paris, France.

ARTHUR P. MURRAY (*A*)
Technicolor Motion Picture Corp., 120 Brookline Ave., Boston, Mass.

ROBERT E. O'BOLGER (*A*)
Eastman Kodak Co., 24 Yuen Ming, Yuen Road, Shanghai, China.

ARTHUR E. PIERSON (*A*)
Technicolor Motion Picture Corp., 823 North Seward St., Hollywood, Calif.

HOMER G. TASKER (*M*)
United Research Corp., 41–39 38th St., Long Island City, N. Y.

DEANE R. WHITE (*M*)
Du Pont Film Mfg. Co., Parlin, N. J.

TRANSFERRED FROM ASSOCIATE TO ACTIVE GRADE

DAVID Y. BRADSHAW (*M*)
Fox Hearst Corp., 460 W. 54th St., New York, N. Y.

LESTER COWAN, Academy of Motion Picture Art & Sciences, 7046 Hollywood Blvd., Hollywood, Calif.

ANDRE DEBRIE (*M*)
111–113 Rue St. Maur, Paris, France.

GLENN E. MATTHEWS (*M*)
Research Laboratory, Eastman Kodak Co., Rochester, N. Y.

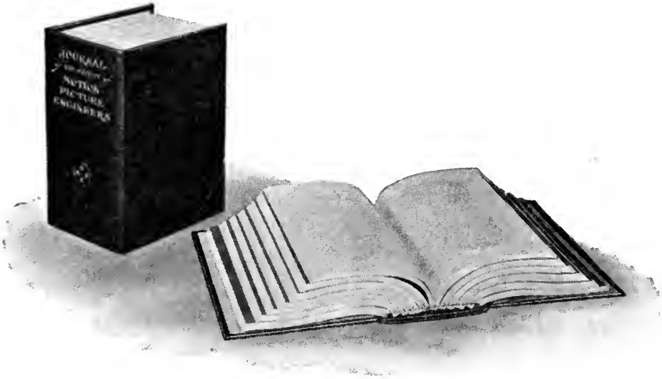
DONALD MCNICOL,
52 Vanderbilt Ave., New York, N. Y.

HARRY G. OTT (*M*)
Spencer Lens Co., 19 Doat St., Buffalo, N. Y.

HARRY RUBIN (*M*)
Paramount Publix Corp., Paramount Bldg., New York, N. Y.

JOURNAL BINDERS

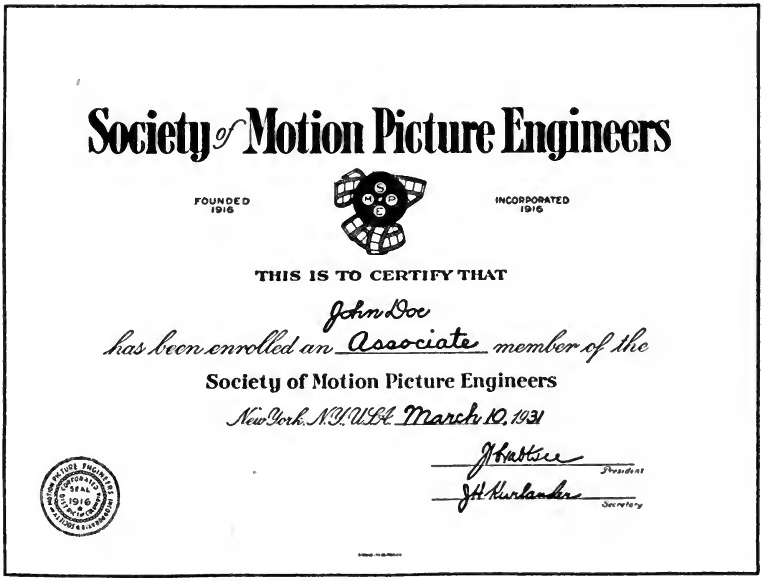
The binder shown in the accompanying illustration serves as a temporary transfer binder or as a permanent cover for a complete year's supply of JOURNALS. It is made of black crush fabrikoid, with lettering in gold. The binder is so constructed that each individual copy of the JOURNAL will lie flat as its pages are turned. The separate copies are held rigidly in place but may be removed or replaced at will in a few seconds.



These binders may be obtained by sending your order to the General Office of the Society, 33 West 42nd Street, New York, N. Y., accompanied by a remittance of two dollars. Your name and the volume number of the JOURNAL may be lettered in gold on embossed bars provided for the purpose at a charge of fifty cents each.

MEMBERSHIP CERTIFICATE

Associate members of the Society may obtain the membership certificate illustrated below by forwarding a request for the same to the General Office of the Society at 33 W. 42nd St., New York, N. Y., accompanied by a remittance of one dollar.


Society of Motion Picture Engineers

FOUNDED 1916 INCORPORATED 1916

THIS IS TO CERTIFY THAT

John Doe

has been enrolled an Associate member of the

Society of Motion Picture Engineers

New York, N.Y. U.S.A. March 10, 1931

President

Secretary

LAPEL BUTTONS

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of one dollar.

SOCIETY OF MOTION PICTURE ENGINEERS, INC.

REPORT OF THE TREASURER

FOR THE PERIOD OCT. 1, 1930, TO SEPT. 15, 1931

Balance, September 30, 1930			$28,580.00
Receipts, Oct. 1, 1930, to Nov. 10, 1930			
(Collected by past treasurer, W. C. Hubbard)			
Dues and Fees			
Dues of active members	$ 3,808.82		
Dues of associate members	1,796.40		
Admission and transfer fees	730.28	$ 6,335.50	
Publication Income			
Journal sales	264.67		
Reprints sales	304.70	569.37	
Other Income			
Interest on bank balances	257.28		
Convention receipts	2,252.50	2,509.78	9,414.65
			$37,994.65
Disbursements during Period			
(Paid by past treasurer, W. C. Hubbard)			
General Expenses			
Convention expenses	$ 2,115.46		
Printing and stationery	53.45		
Clerical help, postage, *etc.*	608.52		
Budget, New York Section (to Sept. 30, 1931)	200.00		
Rent for January, 1931	150.00		
Refunds	10.00		
Protested check	20.00	3,157.43	
Publication Expenses			
Cost of publishing and mailing Journals	154.77		
Reprints	137.41	292.18	3,449.61
Balance, November 10, 1930			
The Plainfield Trust Company:			
Checking account		15,759.85	
Savings account		18,785.19	
Transferred to treasurer-elect, H. T. Cowling; books of General Office opened on this date			$34,545.04

SUMMARY FOR PERIOD NOV. 10, 1930, TO SEPT. 15, 1931

January, 1931, prepaid rent from previous period		150.00	$34,695.04
Receipts			
Dues and Fees			
Dues of active members	$ 2,949.33		
Dues of associate members	2,159.03		
Dues of sustaining members	7,250.00		
Admission and transfer fees	2,289.76	$14,648.12	
Publication Income			
Journal sales and subscriptions	3,402.71		
Reprints revenue	1,808.22	5,210.93	
Other Income			
Interest on bank balances	531.17		
Certificates, badges, and binders	26.00		
Convention receipts	1,363.00		
Overpayments and refunds received	135.52	2,055.69	21,914.74
			$56,609.78

Brought forward			$56,609.78
Disbursements during Period			
General Expenses			
Convention expenses	2,919.31		
Printing and stationery	650.04		
Salaries, management	5,125.00		
Salaries, clerical	2,881.70		
Rent	1,350.00		
Traveling expenses	512.70		
Office expense	1,988.39		
General Society expenses	613.76		
Insurance	38.30		
Outside dues and subscriptions	85.00		
Officers' expenses	549.25		
Board of Governors' expenses	28.30		
Committee and section expenses	1,332.55		
Refunds and adjustments	312.61	18,386.91	
Publication Expenses			
JOURNAL	12,235.39		
Reprints	1,421.12	$13,656.51	32,043.42
Balance, September 15, 1931			
Manufacturers Trust Co., New York:			
Checking account		4,818.21	
Genesee Valley Trust Co., Rochester:			
Checking account		354.48	
Savings account		4,850.90	
Rochester Savings Bank, Rochester:			
Savings account		7,023.33	
The Bowery Savings Bank, New York:			
Savings account		7,519.44	
			$24,566.36

H. T. COWLING, *Treasurer*

(Audited by Robt. W. Sparrow and Co., New York, N. Y., Sept. 15, 1931)

SUSTAINING MEMBERS

Agfa Ansco Corporation
Bausch & Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Carrier Engineering Corp.
Case Research Laboratory
Du Pont Film Manufacturing Corp.
Eastman Kodak Co.
Electrical Research Products, Inc.
General Theaters Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Paramount Publix Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

	No.	Price
1917	3	$0.25
1917	4	0.25
1918	7	0.25
1920	10	1.00
1920	11	1.00
1921	12	1.00
1921	13	1.00
1922	14	1.00
1922	15	1.00
1923	16	2.00
1923	17	2.00
1924	18	$2.00
1924	19	1.25
1924	20	1.25
1925	21	1.25
1925	22	1.25
1925	23	1.25
1925	24	1.25
1926	25	1.25
1926	26	1.25
1926	27	1.25
1926	28	1.25
1927	29	$1.25
1927	30	1.25
1927	31	1.25
1927	32	1.25
1928	33	2.50
1928	34	2.50
1928	35	2.50
1928	36	2.50
1929	37	3.00
1929	38	3.00

Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N. Y., and should be accompanied by check or money-order.

AUTHOR INDEX, VOLUME XVII

CLASSIFIED INDEX, VOLUME XVII